The Engineer

LONDON, FRIDAY, JULY 24, 1942.

PUBLIC NOTICES

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IMPORTANT

Advertisers in Situations Open Column should make themselves acquainted with the terms of

STATUTORY RULES & ORDERS 1941 No. 2069

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The Engineer

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CORRESPONDENCE *re* Accounts and Remittances should be sent in future to:

28, ESSEX STREET, STRAND, LONDON, W.C.2, and NOT to Bath.

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CLASSIFIED ADVERTISEMENTS CLOSE FOR
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The Engineer

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Letters relating to the Advertisement and the Publishing Departments of the Paper are to be addressed to the Publisher; all other letters are to be addressed to the Editor of THE ENGINEER.

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Possil Ironworks, Possil Park, Glasgow
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The Control of Fuel

ON Monday, July 20th, the Control of Fuel Order, 1942, issued by the Minister of Fuel and Power, came into force. Under that Order the Minister will issue specific directions on the supply and consumption of various types of fuel, which can apply to any particular class of persons or premises. The directions issued under the new Order may specify, for instance, the purposes for which, or the circumstances in which, fuel is to be supplied, used, or consumed. Any existing statutory or other obligation which binds a public utility undertaking is relaxed to whatever extent may be necessary to enable the undertaking to comply with the Minister's directions. A further power under the new Order gives to police constables or any persons or class of person authorised for the purpose by the Minister, the power to enter and inspect premises and to inspect and test fuel fittings and appliances. The fuels covered under the Order include coal and coke, paraffin oil, various fuels enumerated in the Order, such as gas and diesel oil, tar, pitch, creosote, &c., and also wood fuel. The Order does not, however, apply to fuels which are used for the propulsion of road transport vehicles.

A New Salvage Order

THE Salvage of Waste Materials Order (No. 3), which has been issued by the Ministry of Supply, came into force on Monday, July 20th. Under the Order no person shall, except under a licence or direction issued by the Ministry of Supply, destroy any rag, rope, or string, throw away or abandon any of these materials, put any of them in a refuse bin or other receptacle used for domestic or trade refuse, or cause or permit any rag, rope, or string awaiting or in course of collection or sale to become mixed with any other material or article, other than rag, rope, or string. The maximum penalties are £100 fine or three months' imprisonment, or both, on conviction in a court of summary jurisdiction, and £500 fine or two years' imprisonment, or both, on indictment. The Order does not prohibit or restrict the use of any rag, rope, or string for manufacturing purposes or for the purpose of saving property from immediate destruction or damage by fire. It is pointed out that old carpets and sacking help to make, among other things, padding for seats in tanks and in mechanical transport vehicles. Waste rope, string, and twine, as well as cotton and linen rags, go into the production of charts for the Navy, maps for the Army and the Royal Air Force, insulating paper, and fibre board. These materials are also used in the manufacture of camouflage netting and ships' ropes, &c. Before the war we imported each year approximately 300,000 cwt. of woollen rags and 400,000 cwt. of cotton rags. Owing to the pressing needs for shipping, it is no longer possible to import these necessary materials.

Accidents on British Railways in 1941

THE annual report of Lieut.-Colonel Sir Alan Mount, the Chief Inspecting Officer of Railways to the Minister of War Transport, issued on Friday, July 17th, shows that in train and movement accidents in Great Britain last year there were 534 fatalities, as against 453 in the previous year. The deaths from train accidents were 50 passengers and 7 railway servants, as compared with annual averages for the five-year period 1935–39 of 17 and 10 respectively. The increase is to be regretted, but the Chief Inspecting Officer does not regard it as surprising under the conditions which prevailed, and feels fully justified in reporting that a high standard of safety was generally maintained. Among passengers the liability to casualty in train accidents was one killed in some 26·6 millions carried. Of the 344 reported train accidents, 157 were caused by human failure, and in many cases it required the cumulative effect of two or three such failures to bring about the accident. In referring to the subject of human failure, it is stated that while fatigue, heavy traffic, and less experienced staff were important elements, the black-out and war conditions generally were factors of at least equal importance. Trains running out of course, the operation of many specials, conveyance of exceptional loads, and abnormal weather all imposed a greater strain on the staff, which was accentuated by an unusually heavy sick list. The incidence of accident, however, has not been materially affected up to now by track, rolling stock, and maintenance difficulties, for which great credit is due to the departments concerned. In accidents connected with the movement of railway vehicles, exclusive of train accidents, 104 passengers were killed, as compared with an average of 68 for the five-year period 1935–39. The majority of these fatalities resulted from attempting to enter or alight from trains (32), falling from trains (31), and falling off platforms (18). It is stated that these accidents were mainly due to misadventure or were caused by want of caution on the part of passengers themselves, and that 52 of the fatalities occurred after dark. Railway servants suffered 314 fatalities in movement and non-movement accidents, against 281 in 1940 and an average of 228 for the five-year period 1935–39. The black-out, it is stated, may have contributed to about 8 per cent. of the casualties, but there was evidence of improvement in this respect as compared with the previous year. There was a noteworthy increase in the number of women employed during the year, and they are engaged in a large variety of occupations. They have proved themselves readily adaptable to their new duties, and are responsive to instructions intended for their personal safety.

The Institute of Fuel

To welcome the Minister of Fuel and Power, Major Gwilym Lloyd George, on his assumption of office, a luncheon meeting, organised by the Institute of Fuel, was held at the Connaught Rooms, London, on Friday, July 17th. Lord McGowan presided, and the guests included the principal officials and Members of Council of many societies interested in the production and use of fuel. In a speech of welcome to the Minister, Lord McGowan said that the active co-operation and experience of the organisations closely concerned with fuel problems would be at the service of the Ministry. Much could be achieved by the right *liaison* between science and industry and between producer and consumer. In his reply, Major Lloyd George reminded the company that coal was a valuable asset in this country, but it was a wasting asset, and the best use must be made of it. The chief task of his Ministry was to see that all the resources of the country were used to the full for the successful prosecution of the war, and the gap between consumption and production would have to be closed. The increased demand which made this gap was good, because it indicated the country's ever-growing war effort. Every effort was being made to see that the right fuel was available for a particular appliance, but the trouble was that there were so many appliances to-day with selective appetites. This made the balancing of consumption with production with greater efficiency more difficult. Every effort would have to be made to eliminate waste in every way. Whilst the immediate task was to win the war, it was necessary to be alive to the fact that the future prosperity of the country depended largely on the most economical use of its fuel and power resources. Thanks to the Minister and to the Chairman were expressed by Lord Dudley Gordon, President of the Federation of British Industries.

Scotland's Coal Resources

IT is announced by the Secretary of State for Scotland that on the recommendation of the Council of State and with the concurrence and close co-operation of the Minister of Fuel and Power and of the Chairman of the Coal Commission, a Committee has been set up to inquire into the present position and future prospects of the Scottish coalfields. The Committee is to report on what measures should be taken to enable the fullest use to be made of existing and potential resources in these coalfields, and what provision of houses and other services will be required for the welfare of the mining community. The Chairman of the Committee is Sir David King Murray, K.C., the Solicitor-General for Scotland, and the members include mine-owners, mineworkers, mining engineers, and experts on local government, housing and planning, as follows:—Mr. James Barbour, President, Scottish Miners' Union; Mr. Thomas Brown, consulting mining engineer, 53, Bothwell Street, Glasgow; Mr. Alexander Cameron, Secretary, Mid and East Lothian Miners' Association; Mr. John Duncan, C.A., of Messrs. Thomson M'Lintock and Co., 216, West George Street, Glasgow; Mr. Peter Henderson, Disputes Secretary, Fife, Clackmannan, and Kinross Miners' Union, Chairman, Scottish T.U.C.; Mr. A. S. M'Kinlay, Deputy Chairman of Glasgow Corporation and formerly Glasgow's Convener of Housing; Mr. F. C. Mears, F.R.I.B.A., Edinburgh, Planning Consultant to the County Councils of East Lothian, Midlothian, and Fife, and the Town Council of Greenock; Mr. William Pearson, President, Lanarkshire Mineworkers' Union; Mr. David Rankine, of Messrs. D. and G. Rankine, mining engineers, 238, West George Street, Glasgow; Mr. Charles C. Reid, general manager, Fife Coal Company, Chairman, Fife and Clackmannan Coal Production Committee; Mr. George J. Sheriff, County Clerk and Treasurer, Stirling County Council; and Mr. J. W. Tweedie, of Bairds and Dalmellington, Ltd., Chairman, Ayrshire District Coal Production Committee.

The Royal Society

AT a meeting of the Royal Society, held on Thursday, July 16th, a gold snuff-box, once the property of Charles Blacker Vignoles, F.R.S. (1793–1875), was presented to the Society by his grandsons, Mr. E. B. Vignoles and Lieut.-Colonel W. A. Vignoles, D.S.O. Mr. E. B. Vignoles, who made the presentation, referred to the fact that in 1841 C. B. Vignoles presented to the Royal Society a fine portrait of Sir Isaac Newton, which had come to him as the result of a connection between his mother's family and that of Sir Isaac. He said that C. B. Vignoles, who was of Huguenot descent, was educated by his maternal grandfather, Dr. Charles Hutton, F.R.S., the mathematician, the author of "Hutton's Logarithms," in the preparation of which Vignoles assisted. As a young man he served for a time in the Army, taking part in the disastrous attack on Bergen-op-Zoom in 1814. Following the peace after Waterloo, he went to America, where he was engaged in survey work in South Carolina and Florida, then very little known. Returning to England in 1823 he was soon engaged in railway engineering, almost his first work being the first survey for the proposed Liverpool and Manchester Railway. In the course of a long career he carried out important work in England and abroad as a railway and civil engineer, including the great suspension bridge over the Dnieper at Kieff and a railway through the Cantabrian Pyrenees from Bilbao to Tudela. The "Vignoles rail," the flat-bottom rail of his design, still used all over the world, keeps his name familiar to railway engineers. The snuff-box, now presented to the Society, was given to Vignoles by the King of Wurtemburg in 1844, as a mark of his esteem, after Vignoles had advised the King on the plans prepared by the King's Ministers and engineers for the railways of the State. Vignoles was elected a member of the Royal Society in 1855 and was President of the Institution of Civil Engineers in 1870–71. The President, Sir Henry Dale, accepting the gift, said it would be treasured by the Society, not only for its intrinsic value, but as a reminder of a distinguished past member.

Model Quality Control Charts

By H. RISSIK, A.M.I.E.E., M. Amer. I.E.E., A.I.I.A., F.R. Stat. S.

No. I

THE increasing attention which engineers are giving to the application of statistical methods to the control of product quality in repetitive manufacture is an indication that this relatively new industrial technique has come to stay. The lead originally given to the engineering industry in this matter at the special joint meeting convened in London a few months ago by the Institutions of Civil, Mechanical, and Electrical Engineers[1] has since been followed, not only in provincial engineering circles, but in governmental quarters also. A statement appeared recently in the official Press announcing that "a study of either or both of the British Standards Institution's publications B.S. 1008—1942, Quality Control, and B.S. 600 R—1942, Quality Control Charts, has been recommended to all production engineers by the Regional Boards of the Ministry of Production."[2] Further joint meetings of the Institutions of Mechanical, Electrical, and Production Engineers have been held in Birmingham, Manchester, and Leeds, at which the applications of quality control to engineering manufacture were keenly discussed; while similar meetings in Sheffield and Leicester have been planned for September and October respectively.

Such growing interest in quality control is, in turn, leading to a demand for (*a*) technical staff competent to initiate and supervise quality control systems in factories, and (*b*) trained operatives capable of working with a quality control routine. The latter demand is successfully being met by the Government training centres, which already, in the last four months, have given instruction in the elements of quality control technique to some 2500 trainees, comprising draughtsmen, draughtswomen, viewers, inspectors, and tool setters, in the twelve centres established throughout the country. In addition, the Ministry of Labour has received several inquiries for inspectors with some quality control experience from firms who are contemplating the introduction of quality control methods into their manufacturing organisations.

Practical Instruction in Quality Control Technique

This last point—the introduction of a quality control system into a factory—raises the whole question of training technical staffs of a supervisory character (*e.g.*, chief inspectors, production engineers, shop superintendents) in the use and application of quality control methods. The need for such training is already being felt. Its satisfaction is of vital importance to the success of quality control in any manufacturing organisation. This demand for technical training in quality control has so far been met only to a limited extent, by arrangements made through the various engineering institutions for lectures by one or two engineers with statistical knowledge and by a statistician with industrial experience. But the time is now ripe for regular part-time lecture courses on quality control which can be attended by the technical staffs of manufacturing firms. This has already been recognised in the Midlands, where, following upon the recent joint meeting in Birmingham, the technical colleges in Birmingham, Coventry, and Wolverhampton arranged for short lecture courses which, from all accounts, were very well attended. Similar instruction has been successfully given under the auspices of the Manchester Statistical Society and by the Enfield Technical College in the North London area.

One of the difficulties in the way of a more widespread development of such lecture courses on quality control is the provision of that practical background without which technical training of this kind loses much of its value and most of its appeal. There is no difficulty whatsoever in planning lectures around the general principles underlying quality control technique, using, say, B.S. 1008—1942 as an elementary guide and B.S. 600 R—1942 as a somewhat more advanced text-book. What the busy factory man wants to know, however, is how these principles work out in practice. How can this new engineering tool be applied to his particular problem? How are his quality control charts to be interpreted? For example, what happens on the control chart for an automatic lathe when the cutting tool begins to wear or the mechanism of the machine itself requires attention? It is precisely such practical questions as these which should be dealt with, and illustrated by actual examples drawn from factory experience, in any training course on quality control, if that course is to prove worth while to the practical man.

In one technical college known to the author, the final lectures were given by two members of the production engineering staff of a local engineering firm which was experimenting with quality control, and they were thus able to produce actual factory control charts for discussion by those attending the lectures. Most technical institutions may not be so favourably placed, however, and some may even hesitate to start a training course in quality control for lack of illustrative material of a practical character. To overcome this difficulty—a very real, if only a temporary one—the author has devised a relatively simple method whereby instructors in technical colleges, and, in fact, anyone interested in the construction and application of quality control charts, can not only make up specific examples of "controlled" production processes, but can also introduce disturbing factors to simulate "uncontrolled" conditions, such as arise in actual practice. The method is based on the use of Tippett's "Random Sampling Numbers" in constructing model quality control charts applicable to the production process which is to be studied and illustrated.

The Statistical Control of Product Quality

The general statistical approach to manufacturing problems, in so far as the control of product quality is concerned, has already been discussed in a previous article.[3] It will be convenient here to recapitulate very briefly the essential characteristics of this approach:—

(1) No repetitive manufacturing process can or will produce articles that are exactly alike. A certain amount of variability from item to item is inevitable under modern conditions of quantity production.

(2) This inherent variability is due to a multiplicity of causes which can be classified into two categories, although in practice the distinction between the two types of causes is by no means absolute. On the one hand, there are the variations due to the operation of forces working at random (*i.e.*, to chance causes), and, on the other hand, there are the variations due to the operation of forces working consistently in some particular direction (*i.e.*, to assignable causes).

(3) The control chart method provides a graphical and thus readily appreciated means of segregating these two fundamental types of causes. The arithmetic of the method is so simple that control charts can be constructed and used by factory personnel with no more than a secondary school education.[4]

(4) The recognition and elimination of "assignable" or non-random causes of product variability, once their presence has been indicated by the control chart, is essentially an engineering problem, whose solution calls for a general knowledge of modern production methods, together with some experience in the diagnosis of production process troubles.

(5) When all such assignable causes have been eliminated from the production process, so that the remaining variations in product quality are due solely to chance causes, the process is said to be in a state of "statistical control" with respect to the measure of quality under consideration. When this state of control is reached, no higher degree of uniformity in quality can be attained with the production process in use.

(6) Only under these circumstances—that is to say, only under conditions of controlled product quality—is it possible to make accurate predictions as to whether or not the production process will yield items whose quality values lie within any specified pair of limits (*e.g.*, purchase specification limits, designed tolerance limits, shop inspection limits).

The ultimate aim of the control chart method is therefore to achieve conditions of statistically uniform or controlled product quality wherein only random causes of variability are operative.[5] As has been explained previously, under these conditions there exists a characteristic relation between particular values of product quality and the frequencies with which they occur.[3] This relation is termed the Normal Law of random variation, and is illustrated by the frequency distributions of Fig. 1. If a sample be taken from a product of controlled quality, the items in that sample will vary in quality among themselves in a characteristic fashion. It will be noted that the larger the size of the sample—that is to say, the greater the number of quality observations made on the

[1] A full report of this meeting is to be found in "Proceedings," Institution of Mechanical Engineers, Vol. 147, No. 3 (June, 1942), while a comprehensive summary of its proceedings was published in THE ENGINEER, April 24th and May 1st, 1942.

[2] "Use of Quality Control Charts," *Board of Trade Journal*, Vol. 148, No. 2369 (May 2nd, 1942).

[3] *Vide* H. Rissik, "Probability Graph Paper and its Engineering Applications," THE ENGINEER, October 24th and 31st, 1941, pages 276 and 296.

[4] *Vide* "The Technique of Quality Control," THE ENGINEER, January 30th, 1942, page 100.

[5] From the practical standpoint, this aim is not necessarily the main desideratum in quality control as applied to production engineering, for example. Here, in assessing the merits of quality control technique, other considerations have to be borne in mind as well. On this point see R. Royan and H. Rissik, "The Statistical Control of Quality in Production Engineering," *Journal*, Inst. Eng. Inspection, Vol. 7, No. 1, January–March, 1942, and *Industry Illustrated*, Vol. 10, No. 3, March, 1942; also "How Creed and Co. Use Quality Control," *Business*, July, 1942.

product—the more regular does the distribution of quality values become and the more closely does it approach towards a smooth curve. In the limit, when the number of observations is assumed to be infinite, the frequency distribution becomes the bell-shaped frequency curve shown in the lower diagram of Fig. 1.

This particular frequency curve, known as

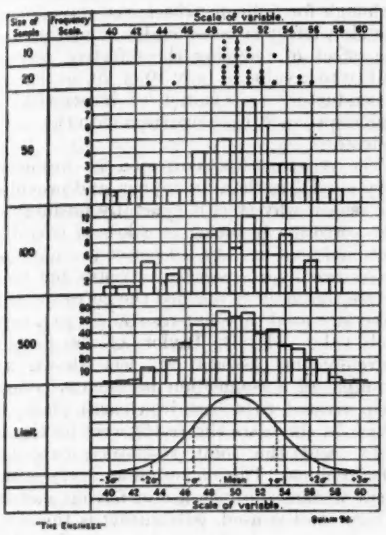


FIG. 1

the Normal curve, is expressed by the equation

$$y=\frac{N}{\sigma\sqrt{2\pi}}\exp\left[-\frac{(x-\bar{X})^2}{2\sigma^2}\right] \quad . \quad . \quad (1)$$

in which x denotes the measure of quality under consideration, N is the total frequency or number of quality observations, $\bar{X}$ is their mean value,[6] and σ is their standard deviation.[7] Equation (1) is more conveniently expressed in the form

$$y=\frac{N}{\sigma}\phi(t) \quad . \quad . \quad . \quad . \quad (2)$$

where $\phi(t)$ is the "generalised" Normal frequency function,

$$\phi(t)=\frac{1}{\sqrt{2\pi}}\epsilon^{-\frac{1}{2}t^2} \quad . \quad . \quad . \quad (3)$$

and t is the generalised variable

$$t=\frac{\text{deviation from mean}}{\text{standard deviation}}=\frac{x-\bar{X}}{\sigma} \quad . \quad (4)$$

The function $\phi(t)$ and its integral, representing the area under the "generalised" Normal curve, have been reduced to standard tables, to be found in almost any text-book on statistical methods.[8]

EXPERIMENTAL MODELS OF CONTROLLED PRODUCT QUALITY

Under conditions of controlled product quality, then, the quality values x may be taken as following the Normal Law of equation (1). Hence we may use the known properties of the Normal frequency distribution, based on observed or assumed values of N, $\bar{X}$, and σ, to construct a model of a manufacturing process yielding a product whose quality is in a state of statistical control. As will be shown later, such experimental models of controlled product quality are of immense value from the instructional standpoint, for they can be used to illustrate the operative features of the quality control method in a manner which makes a direct appeal to the practical man.

Theoretically speaking, the generalised variable t of equation (3), which is "normally" distributed about a mean of zero with a standard deviation of unity, has a range from $-\infty$ to $+\infty$. In practice, however, and as may be verified from a standard table of areas, the effective range of the generalised normal curve is $-4<t<+4$. As a matter of fact, only 63 millionths of the total area under the curve lie outside this range. Hence we may take it as certain that when the quality of a manufactured product is in a state of statistical control no observed value of the quality characteristic x will ever lie outside the range $(\bar{X}-4\sigma)<x<(\bar{X}+4\sigma)$. If we now divide this basic range of variability into a number of equal sub-ranges, corresponding to convenient equal intervals of x on the given quality scale, we can use the standard table of areas to find what proportions of the total area under the normal curve are contained in these sub-ranges. Multiplication of these proportions by the total number N of the quality observations to be included in our experimental model then gives the frequencies with which the several quality values x will occur under conditions of controlled product quality.

The method of constructing a model of this kind is quite simple, and is shown in Table I. Suppose we wish to simulate a consignment of 10,000 articles produced under conditions of controlled quality. The majority of the articles will not differ widely in quality from the average value $\bar{X}$. At the same time a fair number will be either well above or well below average quality, whilst a few will deviate very far from the average. How can we determine, and express in a simple way, the numbers of items in the bulk having different quality values? First of all, we must decide the number of such different quality values x in which we are interested. Suppose we say between 10 and 20. The procedure is then as follows (Table I):—We divide the basic range of four standard deviations on either side of the mean into, say, sixteen equal intervals, to provide a frequency distribution having seventeen cells.[9] The first column in the table shows the values of the generalised variable t, corresponding to the boundaries of the several cells, whilst the next column gives the areas under the Normal curve to the left of the ordinates erected on the several cell boundaries. The values in this column are those given in any standard four-place table of areas.

TABLE I.—*Conversion of the Natural Numbers 0000–9999 to the Generalised Normal Frequency Distribution,* $\varphi(t)=\frac{1}{\sqrt{2\pi}}\epsilon^{-\frac{1}{2}t^2}$.

Cell boundary, t.	Area under normal curve, $\int_{-\infty}^{t}\varphi(t)\,dt$	Numbers from 0000–9999 assigned to each cell.	Cell frequency, f.	Cell mid-point, t.	Scale of variable x.
−4·25	0·0000				
		0000	1	−4·0	$\bar{X}-4\sigma$
−3·75	0·0001				
		0001–0005	5	−3·5	
−3·25	0·0006				
		0006–0029	24	−3·0	$\bar{X}-3\sigma$
−2·75	0·0030				
		0030–0121	92	−2·5	
−2·25	0·0122				
		0122–0400	279	−2·0	$\bar{X}-2\sigma$
−1·75	0·0401				
		0401–1055	655	−1·5	
−1·25	0·1056				
		1056–2265	1210	−1·0	$\bar{X}-\sigma$
−0·75	0·2266				
		2266–4012	1747	−0·5	
−0·25	0·4013				
		4013–5986	1974	0	$\bar{X}$
[0]	[0·5000]				
+0·25	0·5987				
		5987–7733	1747	+0·5	
+0·75	0·7734				
		7734–8943	1210	+1·0	$\bar{X}+\sigma$
+1·25	0·8944				
		8944–9598	655	+1·5	
+1·75	0·9599				
		9599–9877	279	+2·0	$\bar{X}+2\sigma$
+2·25	0·9878				
		9878–9969	92	+2·5	
+2·75	0·9970				
		9970–9993	24	+3·0	$\bar{X}+3\sigma$
+3·25	0·9994				
		9994–9998	5	+3·5	
+3·75	0·9999				
		9999	1	+4·0	$\bar{X}+4\sigma$
+4·25	1·0000				
		Total frequency: N=10000		Mean: $\bar{X}=0$. S.D.: $\sigma=1$.	

Now imagine 10,000 blank tickets to represent our consignment of manufactured articles, and that we number them in succession from 0000 to 9999. The third column in the table gives the ticket *numbers* which must be assigned to each cell, *i.e.*, to each of the seventeen quality values in which we are interested, in order that the resulting cell frequencies (fourth column) will follow the Normal Law. These four-figure numbers are readily found by multiplying the fractions in the second column by 10,000 and then taking successive differences. The fourth column shows the corresponding cell frequencies, *i.e.*, the number of *tickets* falling to each of the seventeen cells, whilst the fifth column gives the corresponding cell mid-point values in terms of the generalised variable t.

Considering the two end cells, for example, we see that only one article out of the 10,000 falls either above or below the average quality by as much as four standard deviations. On the other hand, no less than 1974 articles (20 per cent. of the consignment) will be of average quality. To make the matter specific, the sixth column in Table I indicates the actual quality values x whose frequencies of occurrence are given by the fourth column. Suppose the articles in question were ordinary building bricks, and that their average transverse strength was known to be $\bar{X}=1000$ lb. per square inch, with a standard deviation of $\sigma=200$ lb. per square inch. Then, under conditions of quality controlled manufacture we would expect, for example, 655 bricks to have a strength between 650 lb. and 750 lb. per square inch, or between 1250 lb. and 1350 lb. per square inch, *i.e.*, round about 700 lb. and 1300 lb. per square inch respectively ($x=\bar{X}-1\cdot5\sigma$ and $x=\bar{X}+1\cdot5\sigma$).

Reverting to our 10,000 tickets, numbered consecutively from 0000 to 9999, we would write the strength value $x=700$ on the backs of tickets Nos. 0401 to 1055 inclusive, and the value $x=1300$ on Nos. 8944 to 9598 inclusive. Simliarly, we would write the value $x=200$ on the back of ticket No. 0000 and the value $x=1800$ on No. 9999. In the same way we would write the remaining strength values, proceeding by intervals of 100 lb. per square inch ($=0\cdot5\sigma$), on the thirteen remaining groups of tickets whose numbers are given in the third column of Table I. Our 10,000 tickets have thus become an experimental model of a quality controlled bulk product, having $\bar{X}=1000$ lb. per square inch and $\sigma=200$ lb. per square inch, and consisting of N=10,000 individual items. We shall now see to what practical use such an experimental model can be put.

(To be continued)

[6] *Vide* reference (3), equations (1), (2), or (3).

[7] *Ibid.*, equations (5), (6), or (7).

[8] See *inter alia* J. F. Kenney, "Mathematics of Statistics," Part I (Chapman and Hall, 1940), and W. E. Shewhart, "Economic Control of Quality of Manufactured Product" (Macmillan and Co., 1931). The former is by far the best elementary book on the method of statistics which has so far been published, whilst the latter is the standard theoretical work on quality contro technique. A short table of areas is also given in B.S. 600R—1942.

[9] *Vide* reference (3) for the terminology of frequency distributions.

The Lightning Protection of Buildings

By E. H. W. BANNER, M.Sc., M.I.E.E., F. Inst. P.

No. II

(*Continued from page 51, July 17th*)

Conductor Size

WHAT is the necessary size of conductor to deal with repeated strokes without fusing ? The size is determined not only by electrical considerations, but also by mechanical, as the conductor must be strong enough to withstand handling in fixing and continued strength to remain intact indefinitely. The electrical limit is the primary consideration, but if the conductor size so determined appears to be mechanically unsound, then a larger conductor will, of course, be used. This applies particularly to the air electrodes which, if extending upwards for 5ft., require to be rigid and should preferably be self-supporting.

The electrical consideration is primarily the calculation of a conductor size able to withstand a given quantity of electricity, which becomes a given current for a given short time. A good conductor is the first choice, and copper is generally used, but its great merit is that it is more resistant to corrosion than most other metals. Further, its softness makes it easy to work. The duration of any discharge, either single or multiple, is so short that there is no appreciable heat loss due to radiation, conduction, or convection. Now the amount of heat required to raise the temperature of a conductor through θ deg. Cent. equals

$$H=\theta\, A\, s\, d \text{ gramme-calories}$$
$$=J\,\theta\, A\, s\, d \text{ Joules.}$$

The amount of heat generated per unit length by Q coulombs in T seconds is $H=T\left(\frac{Q}{T}\right)^2\frac{\rho}{A}$ Joules, which may be converted to use figures for current and time, as already adopted, by using the expression $Q=I\,T/2$, due to the triangular wave form which is for this purpose a close approxmation to the exponential rise and fall.

Then

$$H=T\left(\frac{I\,T}{2\,T}\right)^2\frac{\rho}{A}$$

Equating this with the formula for heat required,

$$A\,J\,\theta\,s\,d=T\left(\frac{I\,T}{2\,T}\right)^2\frac{\rho}{A}$$

from which

$$A=I\sqrt{\frac{T\,\rho}{4\,J\,\theta\,s\,d}}$$

where A=Area, square centimetres.
I=Current, amperes.
T=Time=$n\,t$, seconds.
ρ=Resistivity (for copper at 50 deg. Cent., a mean between 0 deg. and 100 deg. Cent.=2×10^{-6}).
J=4·18=Joule's equivalent.
s=Specific heat (for copper at 50 deg. Cent.=0·09).
d=Density (for copper=8·93).

Inserting previously quoted figures for I and T :—

I, kA.	n.	T=$n\,t$, μ seconds.	A, sq. cm.
200	1	50	0·076
200	3	150	0·13
200	10	500	0·23
200	20	1000	0·32

Simpson, using the formula $Q=I\,T$, obtains for his worst case :—

200	20	1000	0·483

the area A from which is greater than that for the triangular wave case by $\sqrt{2}$.

For the case of I=200 kA and n=10, A should be 0·23 square centimetres as a minimum, but a factor of safety is required.

A second method of deriving A by calculation of the quantity required to fuse a given conductor is given by Bellaschi

$$I^2T=(kA)^2,$$

where I=Current, amperes.
T=Time from zero to half value on wave tail, seconds.
A=Area, square centimetre.
k=A constant, for copper=320,000.

Inserting previously quoted figures for I and T :—

I, kA.	n.	T=$n\,t$, μ seconds.	A, sq. cm.
200	1	50	0·0044
200	3	150	0·0076
200	10	500	0·014
200	20	1000	0·02

The above figures are fusing current for A, so that a factor is required to restrict the temperature rise. If this be taken as 11

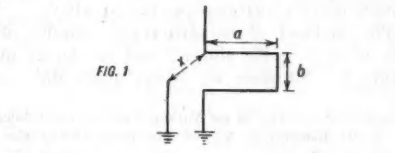


FIG. 1

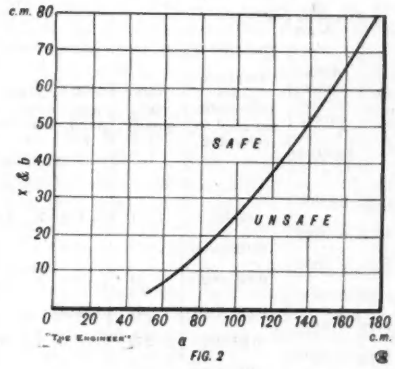


FIG. 2

the ratio of the melting point of copper (1083 deg. Cent.), and a safe temperature of 100 deg. Cent., and the worst case above be taken, the actual area of a copper conductor should be a minimum of 0·22 square centimetre. Thus by both methods a similar result is obtained. Bellaschi also found that in some cases copper conductors up to 0·02 square centimetre were actually fused by lightning, supporting his figures. He recommended copper conductors of 0·3 square centimetre. Walter calculated on a formula due to Vogel in 1888, and gave the necessary area as 0·5 square centimetre. From all these calculations, tests, and theory, the author now considers that for copper a sectional area of 0·4 square centimetre is suitable. This may conveniently be a strip of $\frac{1}{2}$in. by $\frac{1}{8}$in., or a round rod $^9/_{32}$in. diameter, but, of course, mechanical considerations may require a larger section.

Materials for Conductors

Any material used must be satisfactory, not only electrically, but also mechanically, including strength and permanency. Copper, as has been remarked, is generally used. Whilst the ohmic resistance of a conductor will be under 0·1 ohm, the inductive impedance may be considerably more. Steel being a cheaper material than copper, it is sometimes used for this purpose, and its use is worth examination. The ohmic drop may exceed that for a copper conductor, but need not if the area is increased proportionately. But the inductive drop will increase, due to the increased permeability, although for lightning discharge wave-forms the skin effect is considerable, and this has the effect of reducing the effective permeability to a value of only 10 or 20, so that as a conductor steel is not of impracticably high impedance, in comparison with the earth resistance.

The resistance to corrosion is, however, very much less than for copper, and provides the reason why steel is generally unsuitable. The corrosion resulting in a loss of effective sectional area by, say, 10 per cent., may not be serious, over a number of years, but long before this stage is reached the corrosion will have increased the joint resistances to a very high value. H. G. Taylor, of the Copper Development Association, has shown an example of a connection between a copper strip riveted to a cast iron earth plate, in which in six years the rivets were no longer tight, and the joint resistance exceeded 20,000 ohms. This corrosion at joints is the great weakness in the use of ferrous metals. Where steel is used, galvanising is the most satisfactory way of reducing corrosion, but if holes are drilled after galvanising much of the protection is lost. The use of a steel conductor without joints is the only way to avoid corrosion trouble, and this may be done by the use of a steel tube sunk in the ground to be self-supporting, the buried portion contributing to the earth resistance, but ground corrosion is then not negligible. The Lightning Research Committee of 1905 recommended iron in preference to copper.

Where steel is used instead of copper, the sectional area should be increased by $\sqrt{\rho_2/\rho_1}$, where ρ_1 is the resistivity for copper and ρ_2 for steel. This factor is approximately 2·74, and is used by Simpson. The Bureau of Standards uses a factor of 1·7, and Walter gives a factor of 2. Using steel instead of copper, the area should thus be 0·4 square centimetre$\times$2·74=1·1 square centimetre, or 0·17 square inch. A diameter of $\frac{1}{2}$in. is suitable.

The specific heat s and the density d should also be considered, but in view of the factor of safety taken, these factors may be ignored.

Practical Lightning Protection

The general requirements have been given in the previous section, and in this section the practical means of application of the principles are considered. In all cases the maximum degree of protection only is discussed, although it is realised that such protection may only be required for magazines and other buildings containing explosives or inflammable materials, &c., or for historical buildings which are irreplaceable. For most ordinary buildings a lower degree of protection will be satisfactory, and for many no protection at all is economically justifiable, as insurance is cheaper. The local incidence of lightning should also be considered.

The basic protection required for a building where remote conductors can be applied merely consists of the erection of conductors around the site, such that the whole extent of the building is within the zones of protection which may be taken as having a radius on the ground of twice the height where conductors are adjacent, and for the outer conductors a radius on the ground equal to

the height. A continuous conductor joining all the conductor tops is a real assistance if it can be tolerated, and, in fact, a network of earthed conductors above any area provides almost complete immunity below it, as earth wires above power lines have shown. These conductor masts need not have points at the top, but if of wood they should have a straight conductor carried directly to a suitable earth connection at the foot. The copper conductor size should be 0·4 square centimetre, such as ½in. by ⅛in., but a smaller section may be permissible for ordinary buildings, so that the actual size may be determined by mechanical considerations. The earth electrodes should be as detailed later. Alternatively, a metallic structure, tubular or lattice, may be employed, generally self-supporting. In the latter case no extra conductor is required, provided the section of metal is not less than that given above for copper, or 2·74 times greater for steel.

Conductors on buildings, the usual practical case, also require the same general arrangement, air electrodes above the part to be protected, vertical down conductors, and earth electrodes. A tall narrow structure, such as a chimney, is a simple case, as the zone of protection of the one or more electrodes at the top well covers the chimney throughout, but a long low building is more difficult to protect in this way, although because of its low height its lightning risk may be less. To avoid an undue number of electrodes, a large building should have a metallic network on the roof, connected to all the electrodes, to take a lightning discharge that may reach its roof other than at the edges. The detailed requirements incorporate air electrodes (or air termination points, upper terminals, finials, and other terms), roof conductors, down conductors, base conductor, earth connections, and earth electrodes. Of these, the air electrode, down conductor, and earth electrode form the unit, and serve for the building protection at its perimeter. For large roofs where intermediate electrodes are needed, it will not be possible to route a direct down conductor and earth connection, but only to other down conductors and earth connections, *viâ* one or more roof conductors and base conductors. A number of air electrodes, although suitably disposed along the edges of a roof, with less than their number of down conductors and earth connections and earth electrodes, gives incomplete protection, and should be avoided.

Whilst a straight, vertical conductor is the best, in practice this is not always practicable for conductors on buildings, and the effect of loops will be examined. The worst case is obviously one with a long narrow loop having such an inductance that the voltage developed across its open end, $E = -L\,d\,I/d\,t$, is sufficient to cause spark-over, or where a second and earthed conductor approaches the upper end of the loop, as shown in Fig. 1. This case is not so uncommon as may be supposed. It occurs when earth connections are not taken from the base conductor directly from a test point carrying a down conductor, but from some distance away. Here the vertical conductor is the down conductor, the upper horizontal conductor is the base conductor, and the end of the loop the earth connection. The lower horizontal part is then the earth, and sometimes the distance a is seen to be a few feet and b about 1ft. Similarly, loops near the top of a down conductor may be near earthed vertical drain pipes, having a short separation, as at x. The curve of Fig. 2 is approximate, and is based on conductors of 1 cm. diameter and $d\,I/d\,t = 100$ kA per μ second. For given values of a and b, resulting points to the right of the curve represent unsafe conditions and to the left safe conditions. If it is seen to be unsafe, the ratio a/b must be reduced, the ideal case being when $a = 0$.

For nearby earthed objects the factors a and x apply similarly, but in the latter case the voltage rise may be higher due to R I than that due to $L\,d\,I/d\,t$, and larger spacings for x are then needed.

A simple rule determining the necessary bonding of conducting material running nearly parallel with earthed conductors has been proposed by K. J. R. Wilkinson, of the B.T.H. research laboratories, in an unpublished communication. This is based on the simplified assumption that the inductance per metre of any conductor is substantially constant, and does not exceed 2 μ H per metre; that the spark-over voltage for a rod gap is about 800 kV per metre; and that the maximum rate of change of current in a single conductor is about 20 kA per μ second. From this it can be shown that the ratio of any alternative length to the gap length should not exceed 20. This means that a conductor such as a drain pipe running 1ft. from a lightning conductor should be bonded to it every 20ft. If the worst case of 100 kA per μ second is assumed to apply to a single conductor, then the ratio is correspondingly less, namely, 4ft.

Earth Electrodes

Much work has recently been carried out on earth electrodes by Taylor and others, and it has been shown that to attain a given resistance the most economical method, both in material and labour, is the employment of driven rods. These rods should preferably be of copper, and the optimum diameter is ½in. The effectiveness towards reducing earth resistance is reduced slightly as the section is decreased, but a limit is imposed by mechanical reasons, mainly driving without buckling. Convenient lengths are 4ft., and they are provided with an internal screwed thread so that bronze connecting screws may be used, providing a solid conductor having no projections. A steel driving tip may be screwed to the end, and a driving head attached temporarily to the top. A connector is finally added near the top as a means of connecting the leads from the lightning conductors, *viâ* a test point. Such electrodes may be driven by some form of power hammer, and an electric hammer is on the market which serves admirably; but in very hard ground it is impossible to drive more than a few feet, and then the only plan is to drive rods in parallel, instead of connecting them mechanically in series. In either case the separation between electrodes should be not less than their length. The number of electrodes required has already been discussed.

Where several 12ft. electrodes are required at each test point it is better to space them symmetrically about the first one, which should be 12ft. from the test point, the tendency being to spread the current flow around and away from the building. For very high-resistivity ground, the spacing of 12ft. may be increased. If more than three electrodes are required to obtain the desired resistance, the scheme should be examined afresh, and further consideration given it. An electrode comprising three rods, each 4ft., will be driven for about 11ft. 6in., but if driven flush, the upper end, with the connection, should not be in contact with the ground. But where such electrodes are part of an extensive network it may be necessary to drive the rods below ground level, so as to take advantage of the earth connections acting also as electrodes, and for traffic considerations. In this case the ground should be excavated around the electrode top so that the connection is accessible.

The addition of salt around an electrode has been proposed, both for the general case of power earths where a low resistance is required, and for the case of lightning earths, in order to minimise sparking in the ground by increasing the conductivity locally. Coke, ashes, &c., are liable to cause corrosion trouble, and are not recommended. The use of buried earth plates, and especially coils, is strongly to be deprecated, Taylor's work having shown the economic superiority of driven rods and the trouble due to joints.

Testing

As soon as the installation is completed, earth connections should be disconnected at the test points and the individual resistances measured and logged for future comparison.

Testing should preferably be carried out after a spell of dry weather, and, if possible, at about the same season each year, so as to obtain the worst, but fairly consistent, results. Testing should not be carried out when there appears to be risk of lightning—certainly earths should not be disconnected during such conditions, and no earth connections should be left disconnected overnight or during the prolonged absence of the person making the test. Testing of steel conductors should preferably be carried out more frequently than for copper, as corrosion may increase joint resistances rapidly. Annual testing is sufficient for copper conductors.

If on testing any earth electrode its resistance is found to have increased by as much as 50 per cent., it should be examined, and if no apparent fault is found, additional electrodes should be driven as required, until the original resistance is attained.

A self-contained earth testing set is to be preferred. One making use of A.C. in the ground avoids polarisation. Such instruments require two auxiliary test electrodes, a current, and a potential electrode, and they should be spaced as recommended by the maker of the instrument; this procedure is identical with that for measuring earths on power systems.

The author's thanks are tendered to Mr. H. M. Lacey for his interest in and discussion of many of the principles raised, and to Mr. J. F. Shipley for comments.

The Debate on Production

WE give below excerpts from the statements made in the House of Commons by the Minister of Production and the Minister of Supply during the two days' debate on the production of munitions and warlike supplies on July 14th and 15th.

The Minister of Production (Mr. Lyttelton): The last debate on production ended on March 25th, and therefore 3½ months have elapsed since the whole matter was put under review. I think the Committee would wish to know how those 3½ months have been spent. I will therefore confine myself to the three main sections of the subject which I think are of the greatest importance—first of all, the suitability or quality of the weapons which we now manufacture; secondly, some account of the organi-

sation which I have set up; and, thirdly, as far as it can be given, an account of the volume of production and how production is getting on. I put the suitability or quality of the weapons first, because I think it is on that subject that the Committee is most concerned. What steps are taken to get the practical lessons gleaned from the battlefields back to the Supply Ministries, where the design engineers, the development engineers, and the production engineers can work upon them; what arrangements are there for new developments?

First of all, let me discuss aircraft, because I think that in the air technical development is, more than in any other element, the dominating factor in the fortunes of war. There are two representatives of the Ministry of Aircraft Production, the Controller of Research and Development, who is an Air Force officer, and the Chief Scientific Adviser, who is a world-renowned scientist, who are members both of the Air Council and the Aircraft Supply Council. Similarly liaison is maintained with the Navy by the residence in the Ministry of Aircraft Production of two senior naval officers and staff. In this way there is a constant interchange of technical operational knowledge on the one hand, and technical design and research on the other. I think that we have some reason to be proud of the results, and I claim that the aeronautical industry in this country leads the world in adapting itself to the changing conditions which air fighting brings. I am quite convinced that that lead in the air—and I am talking now particularly of quality—with which we started, has been maintained.

Let me turn to the Army requirements. What steps here are used to bring tactical information into the factories? There are two parts of the organisation. The General Staff has, of course, a constant stream of tactical information from the battlefields and from the operations of our troops on manœuvres in this country. That tactical information is sifted and applied to any technical problem, and handed into the Ministry of Supply. That is not all. The second part of the organisation is that highly qualified scientific observers have been formed into operational research sections which are on the battlefield. These operational research sections report direct to the commander-in-chief in the theatre in which they are operating, and direct to the Ministry of Supply, and whatever may have been the case in the early part of the war, this particular marriage between tactical lessons and production practice now works satisfactorily. New enemy equipment, as soon as it is captured is, after a preliminary investigation, of course, sent home to see what lessons can be learnt from it. On this particular subject there is also a Weapon Development Committee under the D.C.I.G.S. from the War Office, and it includes officers from the Ministry of Supply, and the Chief Scientific Adviser of the War Office is a member of the Committee.

During a recent debate I gave a lot of information, past information, about tanks and guns. I think it is very easy to gain a wrong impression from comparing one piece of British equipment with another piece of German equipment. A correspondent called me to task because I had mentioned the 25-pounder as being a very successful gun against tanks in the open. I said it was a slower firing gun. Its rate is eight rounds per minute compared with the twelve to fifteen rounds of the 3·7. He said that I should have mentioned the fact that the 25-pounder had a lower muzzle velocity than the 88 mm. gun. I might well have done so, and I might have gone on to a discussion of the 3·7, which is a comparable pre-war gun, and also in large production. I think that some light might be thrown on the subject of artillery if I gave just another three calibres of comparable weapons. The Germans have an anti-tank weapon of 37 mm., and that corresponds to our 2-pounder. The German weapon throws a projectile of 1·9 lb. compared with the 2·4 lb. projectile thrown by the 2-pounder. The diameter of the 2-pounder is 40 mm. Next in the range is the 50 mm. German anti-tank gun, and that compares with our 6-pounder. The 50 mm. German gun throws a projectile of 4½ lb. compared with the 6¼ lb. projectile thrown by our 6-pounder, so that the 6-pounder is a more powerful gun than the 50 mm. German anti-tank gun, and is strictly comparable. Both are designed as anti-tank guns. I think that the range of the 6-pounder will compare favourably with that of the 50 mm.

Lastly, there is the 88 mm., about which we have heard so much, and the comparative weapon in British equipment is the 3·7. Both these guns are high-velocity anti-aircraft guns. There has been some suggestion that the 3·7 cannot be used in an anti-tank *rôle*. On the mobile mounting exactly the same as the 80 mm., it can be used very effectively. Neither gun is an ideal anti-tank gun, because they are not low enough, but when either of these guns gets a good target of tanks the effect will be devastating. These are exactly comparable weapons.

Turning to tanks, I do not propose to go into the past history, which I ventilated largely in the last debate, but I want to try and give the Committee some assurance that we are making the right tanks now and are going to make the right tanks in the future. First, we sent to the United States a Tank Mission, and it did very good work. That Mission fixed the tank programme and allotted to the United States on the one hand and to the United Kingdom on the other, a programme of manufacture. So if there are any mistakes—and I do not think there are—in the foresight which we are showing towards this tank problem, the programme is one which has been made by the United States and by ourselves. It is a carefully considered programme. Moreover, the tanks that are actually coming out of the production line now will have the necessary fire power for to-day's battle and the new types which are designed to be made in the United States and this country give us a reasonable assurance of that superiority which is required for victory.

Before I leave the general subject of quality, I think I must plunge into a technical subject, and that is the difficulty caused by the pull between mass production and flexibility. This is the constant production problem with which we are faced, because mass production and flexibility are opposite terms. One is the antithesis of the other. The strategist would like to feel that in any theatre of war he is going to have the right weapon available at once, and the tactician requires that tactical lessons should be translated into steel in a few minutes. But the production engineer requires something different. He requires to have types very steady, if possible, and one of the reasons why this is particularly so in this country is that we are using diluted labour to an extent that has never been attempted before. If you dilute your skilled labour, it means more elaborate tooling of your factory, and, again, elaborate tooling is the enemy of flexibility.

It is no good burking the fact that your constant production problem is there; and the greatest ingenuity must be used in striking the right balance between volume production on the one side and flexibility on the other. The tooling for a heavy bomber costing, we will say, £100,000, would be £2,000,000, and for a 6-pounder gun, worth probably £1200, it may be £200,000. You have this very elaborate tooling, and all these tools have to be designed and put into the production line before you produce one thing. It is absolutely necessary to stress that there is an irreducible minimum between the moment when design is, as engineers say, frozen or fixed, and the moment when you can produce the first one off the production line. We cannot reduce that. What we can do is by constant study to try to get the maximum flexibility which is consistent with volume.

Now I turn to the organisation which I have set up. The staff is divided into several sections. The first is the Joint War Production Staff; the second dealing with raw materials, and for convenience I here include allocation of machine tools; the third is the Industrial Panel and Industrial Division; the fourth deals with regional organisation; and the fifth is the section which deals with industrial information. The Joint War Production Staff has been at work since the beginning of March. It represents the three Services. It has sailors, soldiers, and airmen on the staff, with my production staff, and they are at work continuously. Very little work is done in committees, and the top level committee meets very occasionally.

This staff is the central planning organisation of production, and it works out problems which involve many Departments, or which involve policy which is above the power of any one Department to solve. Its main task, I suppose, expressed broadly, would be to give the right proportion of the national effort to each of the three Services and to civilian requirements. At this moment is the balance between expenditure on merchant shipbuilding, on the naval programme, on aircraft, and on Army requirements correct? In 1940 we had to have aircraft or die. In 1941, with the entry of Russia into the war, the emphasis became more on tanks. In this year, with the mounting production of both the United States and this country, we have to look to the means of transporting those weapons to the country where they can fight the enemy. Therefore, recently, the Joint War Production Staff, with the approval of the War Cabinet, have given a higher allocation of raw materials to the merchant shipbuilding and naval programme, and are at this moment in the course of arranging with the Minister of Labour for the transfer of certain skilled labour which will be followed by raw labour, into the shipyards to bring this particular branch of our national effort into its correct perspective. This matter of shipbuilding, again, is closely linked up with the United States shipbuilding programme.

The next subject is the Raw Materials Division and the Machine Tool Control. This, again, I can deal with fairly quickly. This part of the organisation is charged with the allocation of the machine tools, with the fixing of the import programmes for all raw materials. This, too, has to be closely interlocked with the raw materials programme of the United States. This allocation follows the plan fixed by the Joint War Production staffs; and there are officers in this section dealing with the conservation of raw materials, which now, with the massive programme we have, has to be very closely looked into if raw materials are not to become one of the limiting factors over the whole field. One of the ways in which economy can be secured is by cutting down their consumption drastically, and then getting substitutes to replace, perhaps in smaller quantities, some of the things which have been taken away. The changes in the course of the war have made violent changes in our whole raw materials situation. Rubber is an instance. We do not consider at present that we should make synthetic rubber in this country, because there is no saving in shipping unless the synthetic rubber is derived ultimately from coal. The present method is to extract oil from coal first, and then to use that oil for the manufacture of synthetic rubber. Our policy is to concentrate the production of synthetic rubber in the United States.

I should like to deal with the regional organisation on the same lines as I have dealt with the raw materials and machine tools part of our organisation. The Citrine Report was first submitted on May 1st. It was considered by the Government and, in the main, accepted by them, except for one matter to which they have since agreed, that matter being the appointment of the Vice-Chairmen of the Regional Boards. I must say that the old Regional Boards did very useful work, and we owe a great deal to them. At my request, they continued their work until the new Boards were constituted. In appointing the regional controls, my office was in very close touch with the Trades Union Congress and the employers' federations, and I have reason to believe that the appointment of these men was readily acceptable to both the T.U.C. and the employers' federations. I have very high expectations of the contribution which the Regional Boards can make in regard to our production problems. We have reached a point in our production where we cannot look for much more help from getting more labour into our industries. We have to rely on greater productivity from our existing resources. It is not a matter of absenteeism or of harder work, but of better, more detailed planning, greater use of our

machine tools, and better adjustments of loads.

The last subject is the most important of all. The load is now maldistributed in many cases. That is inevitable. We are going to try and put that right through the regional organisations. I was in a plant the other day which was making 100 medium-sized products for the electrical industries. If the number, by redistribution, could be reduced to 50, there would be an increase by 20 or 30 per cent. in the production of that plant without the addition of a single machine tool or a single worker. The other question is that of getting the complicated jobs done by those firms with special skill, and releasing the simpler jobs to the smaller plants, where skill is necessarily less. Another problem is that of firms with big names getting too many orders, while the less well-known firms get too few. That sounds a simple matter, but the problem does occur. In all these matters it is local knowledge that is required and local enthusiasm. We want the personal touch between the regional organisations and the district committees and the various plants.

The Industrial Division is the next subject with which I want to deal, and I will do so very shortly. This division is mainly concerned with co-ordinating matters between the headquarters of the various Supply Departments on special subjects. It has recently produced a scheme for the repair of motor vehicles, which has been approved by ten Departments. It is concerned with the electricity supply industry, water supplies, hand tools, contract and costing procedure, the co-ordination of inspection, and subjects of that sort. The Industrial Panel is composed of very well-known industrialists on a part-time basis, and they are not in any sense a court of inquiry or a coroner's inquest. They are a body of industrialists who can be called upon by any Ministry which has some particularly difficult industrial problem to solve. At this moment, the panel are engaged upon, and will shortly finish, a report upon the dilution of labour in the shipyards; and they are conducting a very wide inquiry, at the request of the Ministry of Aircraft Production, into the time taken in changing from one type of aircraft to another, and are suggesting means by which that interval can be shortened. That was done at his request. I might also mention that this panel was not set up by me only. It was set up by the Minister of Supply, the First Lord of the Admiralty, the Minister of Labour, and the Minister of Aircraft Production. It is a joint effort to help to solve some of the more difficult industrial problems.

And, lastly, the last part of the organisation is that part dealing with industrial information. It is very necessary that we should have some focus, some policy by which all the various production bodies should publicise what they want publicised, and that we should disseminate the information in a co-ordinated way. There is another part of the subject to which I attach particular importance. That is the dissemination of technical skill. I am going to ask every plant engaged on Government work to keep a suggestion book in which all the ideas coming from workers or managements are entered, and I am thinking—I am taking advice on the subject at the moment—of a national system by which special recognition should be given to these ideas, because we want ideas, and if we get them we will acknowledge them and see that they are recognised not only by publicity. I think that we shall get great benefit from such a system.

I must refer shortly to my visit to America. It resulted in the formation of the Combined Production and Resources Board, which I regard as the most important recent step in production, and I must give the reasons. It makes the production of these two countries one. There is a common pool from which each nation can draw in accordance with a prearranged plan. That plan is a strategical plan laid down by the Combined Chiefs of Staff, but once it is laid down there ceases to be a British requirement or an American requirement. There only is an Allied requirement, and that requirement is not related to the establishment, as the Army term goes. It is related to an actual operation of war, to a particular date, to a particular force allotted a particular task in a particular theatre, and this is a matter of very great importance. There is no question that our Forces of equal strategical importance in any of these plans with those of the United States receive the same priority as they do all down the line, from finished munitions down to raw materials with which to manufacture them. The task of following up these requirements, which is done by various Missions, is enormously simplified and expedited, because the whole organisation now has what you may term a master document on which the exact priorities can be determined.

But there is more than that in the Combined Production and Resources Board. Through it we can do three things. First of all, we can save shipping; secondly, we can save skill and plant; and, thirdly, we can exchange technical information. How do we save shipping? I think it is better to give a perfectly simple illustration. The United States will manufacture clothing for our troops in the Middle East and we shall manufacture clothing for the American troops in Great Britain—a saving in shipping. The equivalent in shipping is the saving of one voyage from here to the Middle East or practically that equivalent for every ship that is engaged in the traffic.

With regard to the exchange of technical information, I again think that, between the United States and ourselves, this is a matter of prime importance. I spoke the other day of the great ingenuity and resilience of mind which is displayed by American engineers in this field, but I would not like the Committee to think that engineers here are not constantly conducting researches both into means of easing production and into the simplification of design. I would like to give some actual instances. An important machine gun component took 2½ man-hours to manufacture, and by ingenious re-design that 2½ man-hours has been reduced to 6 minutes, and a great economy in material has been made. Perhaps the money value that has been saved has also some significance. It amounts to £220,000 for 100,000 machine guns. The Bofors platform, which was a foreign design, took 1000 man-hours to manufacture, but re-designed it now takes 230. The 2-pounder barrel originally took 193 man-hours and the far larger 6-pounder is now, by re-design and so forth, being manufactured in 72 man-hours. Again, the Sten gun, which is by far the cheapest and most rapidly produced weapon on conventional design, is another instance of the ingenuity which has been displayed. Components of aero-engines taking 8½ hours now take 3 hours, and in a standard aero-frame we have reduced the material by 25 per cent. and the time by 75 per cent. Nevertheless, I still think that the United States are ahead of us in simplification of design and in substitution of materials. That is not a statistical piece of information; it is just my opinion. We have organised the exchange of technical information between the two countries. We have nothing to be ashamed of; indeed, in many things we are far ahead of the United States, and in saying that I give some weight, of course, to the fact that we started before they did. But in such matters of the dilution of male and female labour we are far ahead of the world. The control of raw materials—a most important part of the war—is carried to a much finer point here. We also lead the world in quality of fighter aircraft, we make the fastest heavy bombers, and in the very wide field of radio detection I think we can claim to be very much in advance of anybody else in the world.

Now I want to touch upon our volume of production and how it is coming off. It is coming off well. It is very difficult to get figures in a shape in which they mean anything. Obviously, individual figures cannot be given, and there is a natural impatience with index numbers. But I have given the matter a good deal of thought, and I think the best thing I can do is to give the long-term and short-term trends. If we take aircraft by structural weight and take January, 1941, as 100, by July 1st, 1941, the index number had gone up to 152; by January, 1942, it had risen to 191, and in June, 1942, to 244, representing nearly two and a half times the starting point of January, 1941. If we look at warlike stores, taking again January, 1941, as 100, production had risen to 153 by July 1st, 1941, to 216 by January 1st, 1942, and to 289 on June 30th, 1942. Production between January, 1941, and June, 1942, has nearly trebled.

I could pick out one or two other items. For instance, guns—2-pounder and upwards—are now producing at the rate of 60,000, and that includes no aircraft cannon. The production of armoured fighting vehicles since January, 1941, has nearly quadrupled, so I think we may say that our volume of production is satisfactory. It will grow; the trend is steadily upward, but there is above us, not a peak, but a plateau where we shall be limited by the amount of labour we can put into our industries and the amount of raw material available. We have now reached the point of mobilisation of our people where we cannot look for increased production by building new plant, because we cannot afford the raw materials or labour; neither can we increase production by cutting down civilian use. Already we have imposed great hardships and sacrifices on our people, and gladly have they undergone them. But we can, out of our existing resources, improve production by better planning, design, and openness of mind.

The Minister of Supply (Sir Andrew Duncan): There is no easy road to the design, development, and production of a tank. It follows therefore that we cannot escape, even at this advanced date in the war, the inherent weakness which this country suffers through not having for many years prior to the war devoted sufficient effort to the research, development, experiment, and production of tanks. We won the Battle of Britain in the air partly because of the valour and endurance of our marvellous airmen, partly because of the inspired effort from the workshops at the time, but also because the fighter planes had been designed as far back as 1937, and even then were the outcome of a long series of experiments of earlier prototypes. The war found us ready with an established aircraft industry on which to expand still further, and shadow factories ready for that expansion. Whatever may be said about tanks, let it be remembered that all that background and all these advantages were denied in the field of tank production.

We started the war with negligible resources, and our losses in France found us, in the middle of 1940, as impoverished as we were when war began. And, of course, with France no longer as an ally, we had to start a new chapter. In the circumstances of the time therefore it was quite impossible for any Department or any Government approaching the problem of tank production to do other than turn their attention, at the very first moment of time, to making the best of such models as existed. Could there ever have been a time when the insistence on immediate production was more pressing than it was then? We had therefore to build up our tank policy under the pressure of the immediate need for tanks, and that urgency and immediate need for tanks lasted well through 1941. Besides building up to safeguard this country against the very serious menace of invasion, we had during that year to supply complements for the Middle East, and we had also in the autumn of that year undertaken a commitment to Russia of very considerable proportions.

The first duty in tank development and design remained for some considerable time the perfection so far as it could be done of the existing models. Of these models there were two infantry tanks, the "Matilda" and the "Valentine." These tanks have had adaptations and have been greatly improved, and for a long time now they have been reliable tanks. The tanks which we sent to Russia have given excellent service under all the conditions of the Russian campaign, and they have given excellent service in Libya as well. Then there is a third tank, namely, the "A 22." I think it is unfair to talk of the "A 22" without bearing in mind the background which has already been explained—the need for numbers. The "A 22" was therefore put into production off the drawing board, and there is no secret that in regard to the question of tank design haste calls for its penalties, and unquestionably these tanks did for a very long time show serious defects as they

came out of production. Inasmuch, however, as they came into production in 1941, they performed a very useful service at home, and they have performed a very useful service right up to the spring of this year, in adding to our sense of security and permitting us to send other tanks abroad—the "Matildas" and the "Valentines." New major improvements have been made in the "A 22" tank in order that it may fulfil the very stringent tests which performance in the field demands, and it is now hoped that it will perform successfully, not only at home, but in other parts of the world.

Besides these infantry tanks, two cruiser tanks, one the "Crusader," were nearing the production line. The "Crusader" came into production early in 1941. It also showed defects in its early production, but these were speedily and successfully remedied, and the "Crusader" during this last campaign in Libya has proven to be a reliable tank.

In addition to building up improvements to existing prototypes, the Government set their face at once to the wider problem of providing for the future. Between August, 1940, and January, 1941, two very significant things happened as a result. The Government sent a Mission to the United States when we were very impoverished, and at that time we ordered the "General Grant" tanks, and the "General Grant" tank is in the Middle East to-day because of the action taken at that time. The "General Grant" tank became part and parcel of the Government's provision in this matter of tanks. The Government did more. With the best brains in the manufacturing industry we at once tested our four different designs, and comparatively soon—it can never be quite soon—we settled upon a new prototype. We decided at the same time that a gun of higher calibre should be put into tanks at the very earliest moment at which it could be done without impeding the flow of production. All these steps were taken as soon as practicable. But something more has happened in the interval. A great body of experience has been built up which was absent when war broke out. A great body of experience is necessary before you can have a background upon which quickly to devise modifications or improvisations. Still more, a body of the soundest engineering quality has been built up which makes it much more certain that the next tanks which come off the line will be really good tanks. That is precisely the kind of background which Germany has had all along, and now that we have established quantity and experience in this country, we can establish quality. I say there is every reason for us to take the view that to-day we are in the position of having at last reached a point when we can rely, not upon production being of such quality as will ensure equal terms, but that in future we can keep ahead.

With regard to guns, early consideration was given to a higher-powered gun than the 2-pounder. The 2-pounder was the gun chosen before the war both for tank and anti-tank purposes. In the technical development of guns I do not think there has ever been any question as to the fact that we have kept well ahead. I hope that that will be appreciated by all, because we run great risks if we depreciate ourselves too much. The 2-pounder gun—it is really a 2½-pounder—in fact proved itself in France to be more than a match for the German counterpart. We lost many of our 2-pounders in France. We knew perfectly well that Germany would improve upon her gun, and the Government made the closest study of the gun situation, but kept in mind that the gun situation, so far as the tank gun was concerned, was very closely related to and wrapped up in the tank situation. There was little purpose in going in for a policy which would make it necessary to curtail the production of tanks at a time when the production of tanks was the first thing you were clamouring for. The 6-pounder, the higher-powered gun, was approved, put into production, and came out of production in very substantial quantities in November, 1941, and that was a very significant performance. The Minister of Production commented recently on how significant a performance it was. To-day the Army have more 6-pounder anti-tank guns than they had 2-pounder anti-tank guns a year ago. Guns were and are available for tanks in greater quantities than can all be put into tanks, but that situation will go on improving all the time from now. It is true to say therefore that no time was lost. In so far as we had to decide on the policy of tanks, the policy on guns followed the policy on tanks.

I wish to repeat that the importance of getting this thing right in our own minds is great because of the reaction in the workshops of the country. The Army have never asked that all the tanks produced should be fitted with 6-pounders. The reason for this is that the advantages of a bigger crew, more rapid rate of fire, and greater supply of ammunition attaching to the 2-pounder make this capable of being a more effective weapon for many operational conditions. I would like from this Committee to say to the workers of the country that we hope they will keep the programme of production going to the full so long as it is required. A fortnight ago there was, as a result of the debate in this House, great restlessness in many factories, and I hope that the Committee will allow me to say to all the workers engaged upon these guns that it is their duty and ought to be their joy to conclude the programmes as they have been designed and put to the factories.

American Copper Mine and Reduction Works

No. I

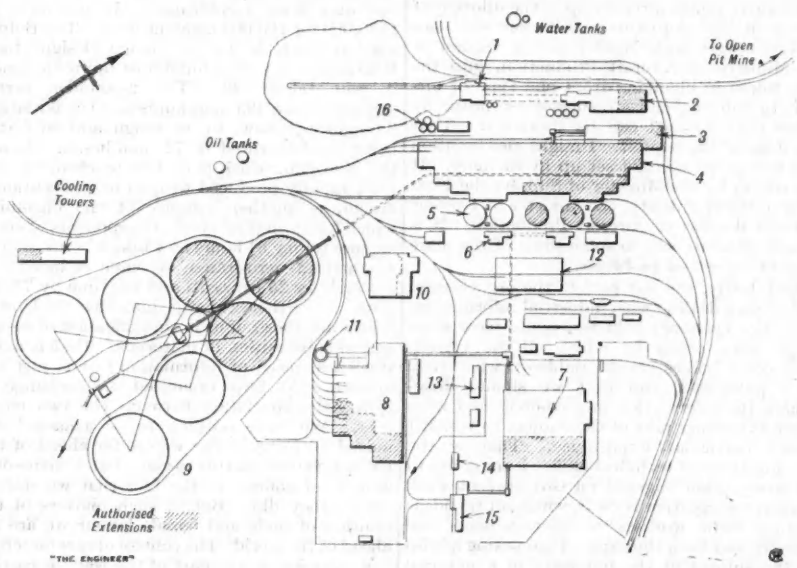
A MOMENTOUS event in the history and development of the copper industry in the United States is the opening, in 1942, of immense works for the mining and smelting of copper from a vast deposit of a sulphide ore averaging only 1 per cent. of copper. The site is in the Morenci district of Arizona, where 900,000 tons of copper have been recovered from a 30 per cent. oxidised ore since a small plant was first established in 1872. Both the old works—still in operation—and the new works are under the management of the Phelps Dodge Corporation.

At the new plant 25,000 tons of ore daily are excavated in an open-pit mine by huge electric excavators, and the reduction works are expected to produce 75,000 tons of copper annually. The following description of the enterprise is summarised from a series of articles published by the American Institute of Mining and Metallurgical Engineers in its *Mining and Metallurgy* magazine. In the general plan, Fig. 1, the present construction is shown, and the authorised extensions are indicated by hatched lines. The principal features of the works are indicated.

Mining of the great deposit of lean ore began a few years ago, and the concentration plant for treating this ore was started on January 30th, 1942. It is thought probable that with the further development of modern methods and equipment for both mining and treatment it will be economically practicable to treat ores averaging only 0·50 per cent. of copper. The present ore body of some 230 million tons averages 1·06 per cent. copper, as determined from small and large drill holes and underground workings. Its present economic depth is about 850ft., with 200ft. of overburden, but drilling was stopped when the samples showed less than 0·50 per cent., so that the actual depth of ore awaits further exploration.

In area the open-pit mine will cover about 350 acres, with maximum length of 6000ft. and width of 4000ft., and a maximum depth of some 1400ft. Stripping the overburden, 220ft. deep on the average, gave about 50 million tons, consisting largely of barren rock overlying the porphyry rock in which the copper is contained. This waste rock was disposed of mainly in the canyons and ravines of the mountain country, and thus formed the base for roadways and railway tracks laid out for the development of the property. Its average haul or lead was about 2¼ miles. The total amount of waste rock to be handled is estimated at 230 million tons.

Drilling and blasting operations were of two different kinds. First, for preparing the lorry roadways and railway lines and starting the



1. Primary crusher plant.
2. Ore storage bin.
3. Secondary crushing plant.
4. Concentrator.
5. Pulp thickeners, 100ft.
6. Pulp filter plant.
7. Concentrate beds.
8. Smelter.
9. Tailings dewatering plant.
10. Power house.
11. Chimney or stack.
12. Machine shop.
13. Laboratories.
14. Lime hydrating plant.
15. Smelter crushing plant.
16. Store-house for reagents.

FIG. 1—PLAN OF COPPER WORKS

excavation benches; secondly, preparing rock for its handling by the 4½-yard excavator buckets. Most of the deep drilling was done with large pneumatic jack hammers suspended from tripod frames, supplemented by drills mounted on wagon frames. The large jack-hammer drills used 1¾in. steels and 3in. starter bits. Smaller drills of the same type, for short holes and for drilling boulders, had 1in. steel and 2¼in. starter bits. All drilling in the pit is wet. For blasting in the deep holes it was generally necessary to spring a powder pocket. Primary drilling on the excavator benches is done with electrically operated churn drills, which bore 9in. holes spaced at intervals of 15ft. These machines can drill about 85ft. in a shift of eight hours. Lines of forty to sixty drill holes are fired simultaneously. The churn drill holes are not sprung.

For the stripping, electric excavators were used, served by a fleet of motor lorries of end-tipping type, having a capacity of 22½ cubic yards. These lorries originally had petrol engines, but most of them were changed to use oil engines, while a few petrol engines were converted to use butane as fuel. The excavators cut a bench sufficiently wide to permit lorries to come on both sides of the machines for loading, thus minimising the arc of swing of the excavator booms or jibs.

Removal of the ore is accomplished by similar excavators working on successive levels or benches, 50ft. apart vertically, and forming an approximate slope of 1 on 1 for the sides of the pit. The top level is at 5500ft. above sea level, and the lowest—as now planned—will be at the 4200ft. level, giving a depth of 1300ft. These excavators are full-revolving machines fitted with buckets of 4½ cubic yards capacity, and operated under the Ward-Leonard control system. Instead of motor lorries for handling the excavated material, as in the excavation of overburden, the ore is handled by trains of dump cars with electric locomotives on a series of switchbacks or reversing inclines having a maximum gradient of 4 per cent. or 1 in 25, compensated for curvature, which is limited to 573ft. radius. The haul on these inclines to the top of the pit is about 2 miles.

A main line of about 1½ miles leads from the top of the pit to the crushing plant, this being all downhill, as the crusher is at 4500ft. above sea level. The maximum gradients are 0·25 per cent. or 1 in 40, and the sharpest curves are of 955ft. radius. Survey and construction of the switchback lines was difficult work, owing to the broken and rugged character of the country, and the formation level is largely on the waste filling. About 80 per cent. of the material excavated is handled by rail, the motor lorries being used now only on the upper levels of the waste rock benches, where the tonnage is not sufficient to warrant the expense of building railway lines.

A transmission line delivers current of 13,800 volts to a transformer station at the edge of the pit, where it is transformed to 2300 volts for secondary distribution lines, from which trailing cables are led to the motor generator sets on the excavators. An output of 4500 tons by an excavator in an eight-hour shift has been accomplished with the usual crew of three men—a runner or operator, an oiler and helper, and a pitman who looks after the connecting electric cable and keeps the railway tracks clear at the machine. Overhead wiring is carried by wood poles, with bracket arms for single lines, while on double lines the poles are in pairs and carry cross-catenary supports. Power for haulage is supplied by mercury-arc rectifiers of 520 kW., which convert the 13,800-volt current to 860-volt D.C. Main lines are laid with 113-lb. T-rails or flat-bottom rails, while bench and dump tracks have 90-lb. rails, all with welded electric bonds at the joints. Creosoted sleepers or ties and slag ballast are used on the permanent lines, and main line curves are equipped with rail and flange lubricators, to reduce curve wear and give easy passage to the trains.

Locomotive equipment serving the pit consists of six oil-electric locomotives of 125 tons weight and 1000 H.P.; similar engines of 100 tons and 600 H.P., and nine combination trolley and battery electric engines of 1325 H.P. These combination engines are used on the ore tracks, which have been electrified from the bench entrances to the crusher house. As the bench tracks are not equipped with overhead wiring, the locomotives work on their batteries when running on these tracks. When the pantograph is in contact with the overhead wire the batteries are charged automatically, and as a rule the engines have this contact for a sufficient length of time to keep the batteries charged for service while this contact is lost. Oil-electric locomotives are used on the upper benches in waste rock, where electric wiring has not been installed.

Car equipment consists of 125 side-tipping, drop-door, double-bogie cars; eighty-five of these, of 40 cubic yards capacity, are used for handling ore, while the others, of 30 cubic yards capacity, handle the stripping or surface rock. A normal ore train consists of ten or eleven 40-yard cars and an electric locomotive, while waste rock trains consist of nine 30-yard cars and an oil-electric locomotive. All cars are equipped with automatic air brakes and have air-operated mechanism for dumping or tipping. With three of the large excavators in operation the average daily tonnage of ore handled is 25,000 tons, and the machines have a maximum record of 6050 tons excavated and loaded in one shift. Ore can be fed to the crusher at a maximum rate of 3400 tons per hour.

Heavy repairs to the locomotives and cars are made at the main machine shop of the reduction works, but ordinary maintenance and light repair work is handled at a special shop for this purpose. The motor lorries are serviced at a well-equipped garage. Miscellaneous railway equipment includes ploughs for levelling the waste at the dumps, locomotive cranes, ballast cars, tank cars to serve the oil engine locomotives, and track-shifting cars to move the dump tracks bodily and keep them near the edge of the dump or waste embankment.

Since the ore loaded at the pit ranges from dust to boulders 6ft. or 8ft. across, only two types of railway cars were suitable for handling it: (1) cars with fixed bodies, which would require to be unloaded by car-dumping machines; (2) side-tipping cars with movable sides or doors, each car having pneumatic mechanism for tipping the body. With the adoption of this latter type of car the high cost of a car-dumping machine is eliminated, and the cars can be used to handle both ore and waste rock.

Allowing a rate of 1·4 min. per car for dumping, and an average of 80 tons per car, a crusher and conveyor system with capacity of 3400 tons per hour would be required. For an output of 25,000 tons of ore per sixteen-hour day the dumping time would be 27½ min. in each hour. This output capacity can be doubled by increasing the number of cars per hour, without requiring any changes in the primary crusher and conveyor plant.

(To be continued)

Sixty Years Ago

HIGH-SPEED STEAMERS

THERE was good reason to believe, we said in a leading article in our issue of July 28th, 1882, that finality had by no means been reached in the speed of passenger steamers. The voyage to New York had not yet been made in 144 hours, but something very near that had been done. Almost every day a new rumour was set afoot in Liverpool concerning steamers yet to be built. The latest was to the effect that two 500ft. ships fitted with twin-screw engines, developing a total of 17,000 H.P. and designed for a regular ocean speed of 21 knots, were to be built in the following year. We doubted whether such ships could be made to pay. They would burn 12½ tons of coal per hour, and, allowing for contingencies, would for the six-day trip require to carry at least 2300 tons of coal. In addition, the space occupied by the engines and boilers would be very great, and as a result there would be practically no room for cargo. Experience showed that it was not easy to make a ship pay which crossed the Atlantic in less than seven days, unless she carried at least 2500 tons of valuable cargo. The new ships would therefore have to rely on high passenger fares for their profits, but it was doubtful, even in these days of desire for high-speed transportation, whether passengers would be found willing to pay excessively high fares merely for the sake of being landed at Liverpool or New York five or six hours sooner than they would have been if they had voyaged by a slower steamer. High-speed steamers for short journeys, such as for cross-Channel services, were, however, in a different class. We believed that the England and Ireland and England and France voyages might be greatly reduced in length by putting improved steamers into service. Developing our ideas, we outlined what we thought the Dover and Calais steamer of the future might be. We thought it would be a ship of about 300 tons displacement, fitted with four locomotive boilers and with engines of about 1800 H.P. The bunkers would be designed to hold about 10 tons of coal. The speed would be 21 knots. Everything would be provided for the passengers' comfort, and no cargo would be carried. For the longer cross-Channel trips a vessel of 1000 tons displacement, driven at 21 knots by engines developing 3000 H.P., would probably be required. The ships would be costly and by themselves would probably not earn a profit. But if, as would certainly be the case, they were owned by the railway companies, their operation would result in the indirect earning of profit.

Parliamentary and Scientific Committee

ON Thursday, July 16th, an important deputation from the Parliamentary and Scientific Committee waited on Mr. R. A. Butler, Chairman of the Scientific Advisory Committee and President of the Board of Education, and asked the Government to set up a full-time Scientific and Technical Joint Board. The deputation, which was introduced by Lord Samuel, included the following:—Captain L. F. Plugge (Chairman), Dr. W. Wooldridge (National Veterinary Medical Association), Mr. C. S. Garland (British Association of Chemists), Professor W. Makower and Sir Lawrence Bragg (Institute of Physics), Professor B. W. Holman, Mr. Gower Pimm (Institution of Structural Engineers), Professor Bernal (Association of Scientific Workers), Colonel Thompson (Institution of Mechanical Engineers), Mr. J. H. Wootton-Davies, Lord Pentland, Mr. Hugh Linstead, Mr. R. B. Pilcher (Institute of Chemistry), Lord Leverhulme, and Viscount Hinchingbrooke. All the members spoke briefly. Captain Plugge said that the deputation had no very clear-cut case to put forward, but it was in general agreed that there was abundant evidence of the need to set up without delay some form of central technical and scientific general staff to ensure that the scientific and technical departments and industry were properly and effectively used in the war effort. The Parliamentary and Scientific Committee had welcomed—with reservations—the establishment of the Scientific Advisory Committee, the Engineering Advisory Committee, and the attachment of many distinguished technical and scientific individuals to all Government Departments, not omitting the Prime Minister's own scientific adviser. Despite all this advice, however, it still seemed, Captain Plugge went on to say, that there was room for a far more effective linking up of production with operational research actually on the field of battle. The deputation would like to see some determined effort to set up without delay a Central Scientific and Technical Organisation which would bring together all the essential information which was available, to link up the scientific and technical direction of the Departments connected with the war, and to influence the War Cabinet and the Chiefs of Staff as necessary in these matters.

The Engineer

JULY 24, 1942

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The fact that goods made of raw materials in short supply owing to war conditions are advertised in this paper or described in its editorial columns should not be taken as an indication that they are necessarily available for export.

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CHANGES OF ADDRESS

*** *Will Subscribers please note that in all advices regarding changes of address it is necessary to have* **both old and new address,** *as our lists are kept alphabetically by towns. Advices of this nature should reach us by the first post Wednesday morning prior to the alteration.*

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Half-Yearly Index

With the object of conserving paper, the number of copies of the Index to Volume CLXXIII will be limited. Copies will be sent to all Institutions and Public Libraries on our mailing list, and subscribers may obtain copies on application gratis and post free.

THE DEBATE ON PRODUCTION

THE debate on production, which took place in the House of Commons last week, presented us with an incomplete picture of the national war effort in so far that while it covered the work of the Minister of Production and of the Ministries of Supply and Aircraft Production, the shipbuilding side of the subject was reserved for a secret session on the third day. On Tuesday, July 14th, Mr. Lyttelton, the Minister of Production, opened the debate with a statement covering the organisation of his Department and giving a limited amount of information concerning the quality and quantity of our current output of munitions. The debate on the first day was closed by Colonel Llewellin, Minister of Aircraft Production, who naturally dealt chiefly with the aeronautical side of the subject. The debate on the second day was concluded by a reply from Sir Andrew Duncan, the Minister of Supply, who dwelt chiefly upon the production of tanks and guns. No one who reads the full report of the debate will, we think, fail to be impressed by the fact that much of the criticism levelled at the three Departments was of a petty character, and, in places, based on misunderstanding or misinformation. Mr. Lyttelton, we think, at the outset made the general position of the country's wartime industrial activity remarkably clear. We have now reached a point, he said, at which little more help can be expected by getting more labour into industry. If we are to increase production we must rely on increasing the productivity of our existing resources. To that end it is necessary to redistribute the production load in a more efficient manner—an object which the Minister hopes will be achieved through the regional organisations—and to simplify design and manufacturing processes. Mr. Lyttelton, however, rightly cautioned members that mass production and flexibility were opposed to one another, and that there were physical limitations to the speed with which new or improved weapons of war could be developed and brought into large-scale production.

Ministers and Government Departments are frequently accused of acting in a manner calculated, in the opinion of their critics, to hamper the national war effort. Doubtlessly they sometimes deserve what they receive. But if the criticism is not itself to react adversely on the war effort, it must be constructive and founded on well-proved facts. Ill-informed accusations and pure fault-finding are apt to depress the morale of our workers and to provide the enemy with opportunities for effective propaganda. It is worse than useless to indulge in mere platitudes. "Machine warfare," said one speaker in last week's debate, "demands quick production, quick changes, quick movement, and quick men," and again, "we need to move with extreme speed in adaptation of types in production, on changed designs where required, and on concentration on new and improved types." Statements of this kind, and there were many such in the course of the debate, make us almost inclined to despair of Parliament as an effective aid to the winning of the war. The tooling equipment for a heavy bomber is said to cost about £2 million, and for a six-pounder gun about £200,000. If a change in design is made the financial loss involved in scrapping the old tooling equipment and in making fresh is by itself, in these days of swollen expenditure, an item of minor importance. The cost of the tooling equipment is, however, significant in that it is a measure of the skilled labour and the time required for its production and therefore of the inevitable delay which must arise in changing from one design to another. Attempts made to introduce changes of design quickly may result, and actually have resulted, in a large amount of wasted effort and eventually in greater delay than would have occurred if the changes had been made more slowly. Instances are known in which much money and time have been expended on the provision of tools and jigs for the mass production of new types of armament which proved to be unsatisfactory and had to be withdrawn from production almost as soon as manufacture was begun. Let us have speed in these matters by all means, but do not let it be the hastiness which defeats its own ends. How long does it take from the inception of a new design of aircraft to its production in quantity? Under peace conditions anything from five to seven years were absorbed. If under war conditions we have been able to cut down that period by half we will have done very well indeed. The "Spitfires" and "Hurricanes" with which we won the Battle of Britain appeared in prototype in 1936. The Hawker "Typhoon" fighter, still under development, was designed in 1937. Our "Stirling," "Halifax," "Manchester," and "Lancaster" heavy bombers were first visualised in a general specification drawn up by the Air Staff in May, 1936. In short, all our fighters and bombers now in operational service are of pre-war design, except as regards modifications of detail. There is, we believe, only one aircraft—an American machine—now in full production which can claim to have been designed since September, 1939. Doubtlessly, the time lag between the conception of a new design of tank or gun and its production in quantity is less than in the case of an aeroplane. But nothing that the Government or anyone else can do will ever reduce it to the short period which some Members of Parliament and other critics outside the House appear to think practicable.

Our enemies, we surmise, are no better placed in this respect than we are. Indeed, certain evidence suggests that they are behind us in adapting their production programme to the constantly changing lessons and requirements of the war. In their endeavour to obtain numerical superiority in the air, they undoubtedly sacrificed flexibility for quantity of production. That policy told heavily against them when in the autumn of 1940 they, for the first time, came up against an efficient, well-served adversary, and all the signs point to the fact that they are still labouring under the defects of their initial policy. In Russia, last winter, by their own admission, their rail and road transport equipment proved inadequate to meet the rigours of the weather. It would be folly indeed to believe that the German General Staff was ignorant of the conditions prevailing in Russia during the winter months. The failure of the German transport equipment arose, it seems certain, from the inevitable time lag required to adapt it to the conditions it was called upon to encounter. In the production of tanks the enemy undoubtedly started with a considerable lead over us, and we have to face the fact, made plain by experience, that we have not as yet fully caught up with them. The time lag in the development of new and improved designs is still telling against us in this section

of our war production, but there is happily evidence to show that we are reducing its effect and that we may soon see it altogether eliminated.

Engineering Education

THERE would be the obvious disadvantage in making now any important alterations to our educational system, except those more or less forced upon us by the exigencies of the times, that the thoughts and energies of many whose opinions would be of great value are wholly absorbed in the task of winning the war. Yet since the stress of war has the effect of throwing into sharp relief any weaknesses, discussion of the subject at the present time, leading, it is to be hoped, to more nearly agreed conclusions as to action that should be taken when the war is over, is by no means undesirable. The recent circulation by the Institution of Civil Engineers, which has, in addition to other major institutions, been giving attention to the subject, of a Memorandum on Engineering Education, abstracts from which we printed in our last issue, has now thrown the whole matter open for comment. This Memorandum is all the more welcome in that its authors have not been afraid to introduce, to comment upon, and even to make recommendations about subjects which have been, and still remain, somewhat controversial.

For many years past the line of development of engineering education has been towards a closer interlinkage of the individual systems developed by the various colleges and universities. In that work the major engineering institutions have played a notable part. A kind of "rationalisation" is being brought about, the trend of which appears to be towards the creation of a line of "stepping stones" between matriculation standard and the degree, followed by the somewhat higher qualifications required for associate membership of a chartered institution; towards facilitating the path of the gifted student from any walk of life who aspires to a university degree; and, with a lesser emphasis perhaps, towards establishing more definitely and more universally an agreed standard for a graduate from any university. This is a change, clearly, that those actively engaged in teaching are peculiarly fitted to encourage and develop. But concurrently with that development there has been growing up a body of opinion that challenges the existing methods of technical education. The pioneers of engineering worked by intuitive methods based on that practical experience of the importance of which all engineers remain convinced to this day. With the growth of knowledge of theoretical fundamental principles, technical education was begun to meet the predominant need of those times for better instruction in those principles. In our day, despite changed conditions, the tendency of the colleges is still to teach "technology" alone, and to offer little or no encouragement to the development of that humanity and broader imaginative outlook so necessary in anyone who is to occupy a post of responsibility. Since we have been amongst those who have deplored this tendency, we welcome the statements in the Memorandum on Engineering Education that the Council of the Institution of Civil Engineers has recently approached the universities urging the inclusion within the curricula of schools of engineering of the study of the "economics of engineering projects, the organisation and management of engineering works, human psychology, and the relations of æsthetic considerations to engineering design," and that a lectureship in "Engineering Economics, Management, and Æsthetics" has been established at Cambridge. "If, therefore, anyone wishes to search out the truth of things in serious earnest, he ought not to select one special science; . . . he ought rather to think how to increase the natural light of reason, not for the purpose of resolving this or that difficulty of scholastic type, but in order that his understanding may light his will to its proper choice in all the contingencies of life." Those words we believe to be as true to-day as they were in the seventeenth century when Descartes wrote them.

The Memorandum of the Institution of Civil Engineers refers also to another subject of importance which has been thrown into greater prominence by the effects of war. There exists a great body of people whose attainments, though insufficient to qualify them for corporate membership of the major institutions, are high enough to enable them to collaborate usefully with chartered engineers. The question of the means to be adopted to bring these people into a connection closer than exists at present with the major institutions is one of considerable complexity. But if a solution can be found it should be fruitful of results of considerable benefit, not only to those at present barred from membership of the greater institutions, but to the general power and prestige of all engineers.

Literature

Short-wave Wireless Communication. By LADNER and STONER. London, 1942: Chapman and Hall. Price 35s.

THIS book, now in its fourth edition, has been improved by rearrangement and the addition of much new material and new diagrams. The added matter is in part didactic, in part descriptive. But the structure of the book, in spite of considerable rearrangement, still reflects the difficulty of giving logical order to this many-limbed subject—radio. It begins with two chapters on general matters, then plunges into the theory of modulation, and then goes to the science of propagation and the ionosphere. There follow three chapters on feeder lines, aerials and arrays; four chapters on amplifiers and oscillators; then Chapter XIII harks back to modulation. Later sections describe commercial plant. The book closes with a chapter on high-frequency therapeutics. Why therapy appears in a work on communication engineering is a mystery—unless, indeed, communication engineers working near a big transmitter like to know what happens to their insides!

The two opening chapters include an historical section on the development of long-distance communication by short waves. This is chiefly in praise of the work of the Marconi Company's engineers and gives the impression that the rest of the world also ran. But enthusiasm leads on to poetic licence. For example, it is stated on page 10 that the Marconi Company's experiments at Poldhu in May and June, 1923, saved the British Government from embarking on the construction of big long-wave stations throughout the Empire. On looking up the technical Press of the date, the reviewer finds that in February, 1923, the British Government decided to drop the long-wave scheme, excepting for the construction of one station (Rugby), which was to be built for strategical reasons. It seems likely that the Poldhu experiments were the consequence of this announcement. They proved that waves concentrated into a beam by aid of a parabolic reflector gave stronger signals up to 2000 miles than when not thus concentrated. Distances far greater had been experienced during the previous winter by Government laboratories and amateurs using simple antennæ.

Chapter III on modulation theory is carefully written and easily understandable by beginners, though frequency and phase modulation are treated too briefly to be clear. Chapter XIII, which deals with the practical side of amplitude modulation, is a contrast; the beginner will probably be baffled by the hurried pace and the half explanations. But if he perseveres he will obtain a good grasp of the modulation circuit supplied by the Marconi Company. In this chapter, by the way, the oscillations must be traced through some of the diagrams in the contrary direction to that of the rest of the book.

The chapters on short-wave propagation are well written and sound, except for a little hesitation in the region of circular polarisation. Chapter VI on high-frequency feeders gives the essence of transmission line theory, simplified by neglecting resistance and leakance, as is justifiable here. Certain omissions consequent upon the approximation are, however, made good in an appendix, so honour is satisfied. The mathematical discussion of aerials and arrays in the succeeding chapters is conducted in the same simplified vein and is a good introduction to the subject. Stress is laid on the great contributions of the Marconi Company's engineers to this technology.

From this point onwards theory gives place to practice. Noteworthy sections are those on power amplifiers, on the cutting of quartz crystals, and on electron oscillators. Then descriptions of super-regenerative and superheterodyne receivers follow, culminating in a detailed description of the Marconi receiver, type "CR 100." An excellent chapter on commercial wireless telephony is followed by one on the 100-kW short-wave transmitter supplied by the Marconi Company to the B.B.C. Then comes light relief in the shape of the chapter on high-frequency therapy, which is interesting and may prove useful to rheumatic readers.

As a whole the book is up to date, but uneven in texture. Sometimes it mentions the originator of a method or apparatus, sometimes it does not, and sometimes it it gives the wrong name. There are also vacant places—places wherein should be discussed such matters as mobile radio-telephony for ships and for aircraft, methods of locating aircraft in flight, of guiding them and of landing them by instrument, and methods of transmitting and receiving frequency modulated waves. Perhaps these vacant places will be filled in future editions.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

FRENCH LOCOMOTIVE PERFORMANCE

SIR,—Mr. Robson very rightly stresses the quite unequalled performance of the Chapelon compounds, and puts forward the explanation of their success as being in a large measure

because they are, in fact, compounds and can therefore achieve high rates of expansion with late cut-offs, and consequently large steam port openings.

This seems very reasonable and logical, but is it supported by the facts? Monsieur Chapelon has published very full particulars and data of the P.O.-Midi 4–8–0 locomotive, and in this a series of indicator diagrams is given for various cut-offs and for a range of speeds from 30 to 65 m.p.h. The shortest cut-off, 20 per cent. high-pressure and 30 per cent. low-pressure, shows no reduction in tractive effort from the lowest to the highest speeds, whereas the later cut-offs show a progressively increasing drop in tractive effort as the speed increases, until at the longest cut-off, 65 per cent. both cylinders, the tractive effort at 65 m.p.h. is little more than 75 per cent. of that at 30 m.p.h.

Again, Mr. Robson suggests that if the simple be given valves large enough to ensure adequate openings to steam at short cut-offs there will be excessive clearance space. Surely this is hardly a point on which the compound is likely to score. All successful compounds have large clearances for a fairly obvious reason, and these Chapelon rebuilds are no exception. The 4–8–0 has 25 per cent. clearance in the high-pressure and 16 per cent. in the low-pressure. That of the first L.M.S. 4–6–2 was given as 8 per cent. Incidentally, the large high-pressure clearance of the 4–8–0 is not wholly due to the large passages, and has evidently been purposely put at this figure as being considered the most suitable compromise by the designer, but it is obviously quite large enough to make the actual expansion ratio very considerably less than is apparently indicated by the high-pressure cut-off and the high-pressure/low-pressure ratio.

I am not criticising the Chapelon rebuilds; far from it. But it does not seem quite apparent why they give such a superlative performance. The steam is, of course, used very efficiently, but, even so, the large power developed requires a great quantity of steam, and in view of the size of the boiler of the 4–8–0 in particular, this achievement seems even more remarkable than the efficiency with which it is used. I suggest that this question of a very free steaming boiler plays a large part also in the success of the Collin 4–6–2s, which have the same type of boiler as the P.O.-Midi 4–8–0s, and Monsieur Chapelon has put it on record that the 4–8–0 boiler was inspired by the success of the Collin design.

C. M. KEILLER.

Esher, Surrey, July 16th.

SIR,—Mr. Robson's letter published in your issue of July 10th certainly quotes some remarkable performances by locomotives rebuilt by Monsieur Chapelon, but it is unfortunate that in comparing these performances with the work of simple engines your correspondent makes statements that are distinctly wide of the mark. While fully endorsing his admiration for the Chapelon engines, I do not think that the capabilities of some existing British simple locomotives should be underestimated.

Commenting upon the continuous output, for 70 miles on end, of 2390 D.H.P., and pointing out that this represents a draw-bar pull at 68 m.p.h., equal to 29 per cent. of the normal tractive effort of the locomotive when working compound, Mr. Robson then asserts that a simple engine could not exert a pull of more than 15 per cent. of its nominal tractive effort under comparable conditions of working. In 1936 a test, with the dynamometer car, was made on the L.N.E.R. "Pacific" engine "No. 2509 (Class A 4)" on which a speed of 78 m.p.h. was sustained up a gradient of 1 in 200 with a load of 270 tons behind the tender. The draw-bar horsepower, allowing for gradient, was approximately 1880, corresponding to a draw-bar pull of 4·1 tons. This is equal to 25 per cent. of the nominal tractive effort of the locomotive, and was achieved on a cut-off of no more than 18 per cent.

Mr. Robson states that with simple expansion the full advantages of high steam pressure and high superheat cannot be realised on more than about 15 per cent. cut-off. The various three-cylinder simple engines designed for the L.N.E.R. by the late Sir Nigel Gresley were designed to work on 15 per cent. cut-off, and were habitually driven so, with entirely satisfactory results. The following table gives some performances noted from the footplate personally by the writer. In each case the draw-bar horsepower has been calculated, using the Johansen formula for train resistance, and corrections made for gravity in the cases where the particular observations were made on an incline.

Engine, type.	Engine, class.	Speed, m.p.h.	Cut-off, per cent.	D.H.P.	Proportion Draw-bar pull / Nominal T.E. per cent.
4–6–2	"A 4"	79	15	1700	23
4–6–2	"A 4"	67	22	2060	32
2–8–2	"P 2"	45	25	1850	36
2–6–0	"K 3"	41	28	1490	45
4–6–0	"B 17"	36	30	1066	43½

It will be seen that at 67 m.p.h. the streamlined "Pacific" engine actually showed a higher proportion of draw-bar pull to nominal tractive effort than the Chapelon machine at the same speed—32, against 29 per cent.—though the cut-off was 22 per cent., against an estimated equivalent cut-off of 17 per cent. on the French compound. The astonishing rise in relative power output between the equivalent cut-off of 17 per cent. and the 25 per cent. quoted in the uphill performance on the 1 in 100 gradient makes one question whether the Chapelon engine was not working "reinforced compound" with live steam being admitted to the low-pressure cylinders, though the low-pressure cut-off of 50 per cent. seems a little short for the latter process to be effectively used. The power output of the Chapelon engine at 47½ m.p.h. is amazing, with draw-bar pull as much as 55 per cent. of the nominal tractive effort, though the L.N.E.R. "K 3" engine, with a ratio of 45 per cent. at 41 m.p.h. and 28 per cent. cut-off, was certainly putting up a good show. With 15 per cent. cut-off and full regulator, the Gresley streamlined "Pacific" engines were capable of speeds between 75 and 80 m.p.h. on the level, with loads of 500 tons behind the tender.

O. S. NOCK.

Chippenham, Wilts, July 17th.

SIR,—It is not my intention to continue the long-standing controversy on the merits of simple *versus* compound locomotives, but I do desire to rebut the charge of "implacable" opposition to the compound principle. Mr. Nock's choice of words was not a happy one.

As you wrote in your leading article of July 10th, "science implies logical thinking." One of the advantages of a scientific training is that it tends to develop the ability to think logically, and is therefore the antithesis of "implacable" opposition.

The indicator diagrams published with my letter in the issue of May 22nd were not intended to be a criterion of the performance of a modern compound engine, and it was clearly stated that they were taken from an engine with obsolete valve setting. They were given because they showed the marked advantages of compounding at low speeds and long cut-offs. Attention was drawn to the pronounced wire drawing in the fourth diagram, taken at a speed of 65 m.p.h., a defect from which the French engines also suffer, as is apparent in the data relating to the tests on the Breville engines, in which a drop of 33·8 per cent. of the steam chest pressure was recorded for a cut-off of 30 per cent. at 56 m.p.h. A similar defect is clearly revealed by the graphs published in the issue of May 1st.

Your leading article, entitled "High-powered Locomotives" (June 26th issue), points the moral of developments in cylinder and valve gear design. To reduce the steam consumption from 26 lb. to 17·5 lb. per I.H.P. surely points the way of things to come. Your correspondent Mr. Robson draws attention to the very large clearance volumes inseparable from piston valves of large diameter. It is impossible to combine steam passages of ample area with small clearance volumes, although careful attention to design can minimise the effects of clearance. In this respect some modern designs give evidence of such care in that the piston valve heads are spaced far apart to give straight steam passages to the cylinders—in marked contrast to some of the earlier designs of piston valves. Mr. Robson has aptly stated that the chief advantage of the compound is the "much less restriction through the cylinder ports than with a single-expansion locomotive, the longer cut-off with the compounds for the same ratio of expansion resulting in the improvement in the three conditions which influence admission."

E. B. PARKER.

Little Sutton, Wirral, July 17th.

AN ENGINEER'S WAR

SIR,—The timely letter of your correspondent, Mr. W. N. Hallett, is in many respects unanswerable, but I have a feeling that the engineers themselves are largely to blame. What share do they take in the ordinary public life of the community in peacetime? Very little. For reasons which to them no doubt seem sound enough, they are content to leave the direction of affairs to others, contenting themselves with the daily tasks of their profession. Usually they profess a contempt for the conventional publicist, law makers, and the commercial magnet who is directing technical industry. It has almost become a convention in our society that the engineer is what has recently been so aptly described as the "back-room boy," the direction of whose efforts is in the hands of that section of society who follow publicity, politics, and commerce.

Take, for instance, the boards of directors in the large engineering industries. How many engineers do we find? Answer: Very few. Your correspondent has cited the absence of the engineer in the higher councils of the Services. This is only too apparent, I agree, but here again this state of affairs is conventional. If this is the position of the engineer in the normal life of the community in peacetime, how can we expect him to emerge during the present catastrophic struggle, and direct our efforts in war production? Take the simple case of public service, either in Parliament or in local government. How many engineers even interest themselves in these affairs, much less devote their time or energies towards those ends. No, as a class they have been content to get on with their own profession and to leave the "direction" to those who, for one reason or another, are in the saddle.

That a technical job, be it peace or war, should be best directed by technicians would seem a *sine qua non* to all but the English (as witness the engineering industries of Germany, America, &c.), but my belief is that our engineers have themselves to blame, although the loss falls not upon them alone, but upon the nation in times like the present.

If there is any doubt, turn over the pages of the "Proceedings" of any of our institutions and look for any sign of anything approaching policy in their deliberations; you will look in vain.

SERVING OFFICER,
M.I. Mech. E., A.M.I.E.E.

July 20th.

CHEROKEE DAM ON THE HOLSTON RIVER, TENNESSEE

The Cherokee Dam

No. I

THE Cherokee dam, on the Holston River, 28 miles north-east by air from Knoxville, Tenn., has been reared at an unusually rapid rate by the Tennessee Valley Authority as a response for more power for industries engaged in national defence activities in that section of the United States.

Congress authorised the Cherokee project on July 31st, 1940, agreeably to a report made by the Council of National Defence about a month earlier, in which the need was pointed out for an added 300,000 kW to the existing power capacity of the several plants then operating under the T.V.A. More defence metals and materials—especially aluminium—were needed and with all practicable dispatch. Steps had to be taken to increase the output of electric energy in the Tennessee Valley, despite restricted rainfall and recurrent droughts, and it was recognised that this could be accomplished only by utilising still further the available water resources of the region. Accordingly, work on the Cherokee dam was taken in hand the day following Congressional authority to go ahead.

Originally scheduled to be so far advanced toward structural completion that the dam could be closed for the impounding of water on January 1st, 1942, actual closure was effected on December 1st, 1941, and this acceleration was achieved by beginning the placing of concrete in the main blocks of the dam two months earlier than had been called for by the approved schedule of operations. This record is understandable when it is recalled that the T.V.A. has an experienced technical personnel that has been developed into a compact smooth-working unit since its creation in 1933; and this organisation has been able to prepare essential plans and cost estimates of projected structures with a minimum of delay. Further, the T.V.A. owns its construction equipment, and carries out its building operations under the immediate supervision of its personnel.

The Cherokee dam blocks the Holston River at a point 52·3 miles above the confluence of that stream with the Tennessee River. The conformation of the valley at the site has lent itself to the rearing of a comparatively high dam and the creation of a reservoir extending upstream for 58·5 miles and capable of storing at high-water elevation a total of 1,566,400 acre-feet. It will have a maximum drawdown of 95ft., representing a usable volume between El. 1075 and El. 980 of 1,473,400 acre-feet of water for power and river control purposes. The dam is composed of a concrete power-house and flanking gravity concrete sections, including a spillway section and two non-overflow sections, the latter adjoining an embankment section on each side of the river formed of a combination of earth and rock fills. The dam crosses the river on a generally north and south line, and where there are depressions in a narrow ridge on the south side of the stream these saddles are closed and brought up to the crest elevation of the main dam by rock and earth fills at three points. The total length of the main dam is 6860ft., and from the lowest excavation, along the axis to the gradient of the surmounting service bridge, the dam has a maximum height of 212ft., the spillway crest being 39ft. lower. The saddle dams are, in their order from north to south, 950ft., 314ft., 705ft., respectively, in length.

To reach the site of the Cherokee dam the T.V.A. had first to build an access railway 4·5 miles long and tapping the Southern Railway to facilitate the subsequent movement of heavy freight to the construction village and storage facilities near the dam site. The construction village contains five large bunk-houses, a recreation building, a mess hall, hospital facilities, field offices, workshops, &c. The camp is typically modern, with an ample water supply, sewage and other hygienic provisions. Within the construction area were built 10·5 miles of rock-surfaced roads to promote carrying out the work in moving materials rapidly from point to point. The field force at peak of operations was 2786 daily workers.

During the first month of field operations timber crib cofferdams were erected in the dry on both sides of the stream, the cofferdams being built behind dykes thrown up for the purpose while the river was low. The cofferdams were erected transversely with three bays and the centre bay was sheathed on each side with 1in. boards and filled with earth from trucks, after which the fill was sluiced to form an impervious barrier. The flanking bays were filled with rock to provide ample stability and on the river side of each cofferdam the crib work was faced with 1in. boards to check any wash by the stream. An opening between the opposing cofferdams

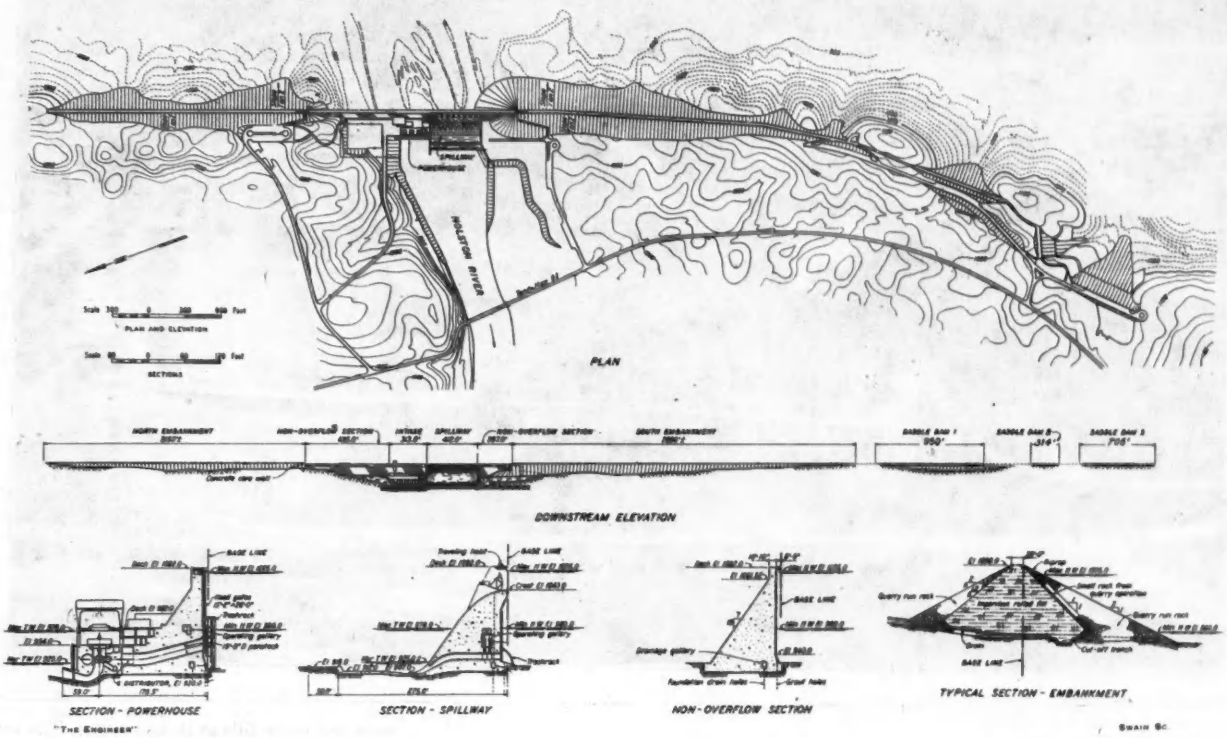
was left 105ft. wide for the flow of the river in its natural channel. The cofferdam on the south side of the river enclosed two blocks of the gate spillway dam, the south side concrete training wall and seven blocks of the concrete bulkhead, the latter tying the spillway sections with the south embankment. The cofferdam on the north side of the river enclosed two gate spillway sections, the concrete training wall, the power-house and sixteen blocks of the north bulkhead section of the dam; the bulkhead connects the intake section of the power-house with the north embankment. With the cofferdams completed, earth and rock excavation was started within the first and second month of field operations.

The rock forming the foundation of the Cherokee dam is what is known as Nolichucky shale, and in some areas rather deep excavations were made to obtain satisfactory bearings for the superposed structures. The shale was found to contain numerous inclusions of limestone, having in most cases a thickness of less than 12in. In the river channel, the hard weathered rock had but little, if any, covering, but across the flood plains, the shale carried a deep overburden of alluvial material, and a shallow blanket of the same nature covered the rock beyond the flood plains. In the limestone strata especially there were evidences of solution, but none of this was found in the shale. However, the shale had weathered to considerable depths under the embankments, and an early removal of the overburden permitted an expansive inspection of the superficial rock structure, and a more intimate knowledge of the rock was obtained by sinking a large number of shafts with 36in. core drills. This gave both the geologist and the engineers opportunity for close internal study of the formation. Care was taken not to expose the foundation shale needlessly to the disintegrating action of the atmosphere, and final excavation down to prescribed gradients was delayed until just before placing concrete or embankment materials for the different sections of the dam.

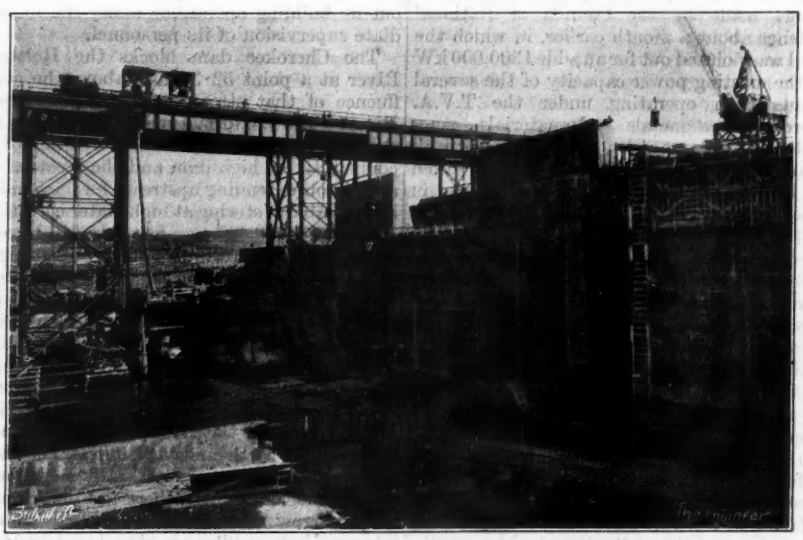
Foundation areas for the embankments and the saddle dams, beneath the rolled-fill portions, were stripped of any organic material, and under the rock fill slopes of the embankments of the main dam—upstream and downstream—the shale was excavated to depths necessary to reach strong rock that would provide ample bearing and be capable of resisting shearing stresses. A cut-off trench, the entire length of each embankment, was excavated into firm shale beneath the upstream toe of the impervious rolled-fill core. This trench has a minimum depth of 4ft. and a maximum depth of about 45ft.

Somewhat extensive grouting, both for consolidating the ground and for creating a curtain to arrest percolation and seepage through the foundation, was used. The grout curtain was formed from end to end of the concrete dam and the adjoining embankments, and even extends into parts of the contiguous reservoir rim. Conventional cement grout was used for the curtain throughout the concrete dam and the embankments, but cement-and-clay grout was employed to stabilise the rim areas. The curtain, under the concrete dam, parallels the axis and is close to the upstream face of the concrete structure. The curtain penetrates to a depth of 100ft. below the base of the dam and was formed by drilling a line of closely spaced holes into which grout was forced at pressures of from 30 lb. to 100 lb. per square inch.

Where cement-and-clay grout was used



PLAN, ELEVATION, AND SECTIONS OF CHEROKEE DAM



SOUTH END OF SPILLWAY AND SOUTH TRAINING WALL UNDER CONSTRUCTION

to stabilise the ground along sections of the reservoir rim, north and south of the main dam, the grout had a thick consistency and was injected at a pressure of but 5 lb. per square inch. That pressure was adopted to prevent, as far as possible, the spread of the grout beyond the limits required to form a water barrier. Where it was necessary to seal existing seams and joints in rock under the concrete dam, consolidation grouting was done, and the grout was applied at a maximum pressure of 30 lb. per square inch. The holes for this purpose were sunk with a wagon drill to a depth of 30ft. and arranged in a rectangular pattern, 24ft. by 30ft. The treatment is said to have given an excellent check on the foundation conditions.

The placing of concrete began in the south cofferdam on December 30th, 1940, within which were poured 1½ blocks of the gate-spillway section to a low elevation. It was over these low blocks that the river later was free to flow while concrete blocks were poured across the previous passageway for the stream. The first concrete placed in the north cofferdam was poured early in the second half of January, 1941, and a few days later the concrete-placing trestle was completed within the south cofferdam. In the last week of the succeeding month of March, the concrete-placing trestle within the north cofferdam was in place. The pouring of concrete within the two cofferdams proceeded rapidly thereafter, and on May 20th, 1941, the original gap between the two cofferdams was closed by concrete blocks, and the flow of the river was carried over the low blocks previously poured in the first stage of the south cofferdam.

The construction trestle, equipped to handle concrete and other materials in connection with the building of the dam and the power house, was of steel, and 98ft. high, and supported a deck on which were laid three tracks of standard gauge. The structure had a total length of 1745ft. and extended from bank to bank of the river. The centre line of the trestle was placed 107ft. downstream from the upstream face of the dam. The deck of the trestle was established at an elevation, 82ft. below the crest line of the dam. The steel columns for the trestle rested on concrete footings rising from foundation rock, and as successive lifts were poured, of the various concrete blocks of the dam, the steel columns were progressively embedded in the rising masonry. While this type of construction trestle has been extensively employed in the building of other dams by the United States Government, the Cherokee dam is the first one on which it has been used by the T.V.A. When the trestle has served its purpose, the embedded steel columns will be cut off flush with the surface of the concrete. During the peak period of concrete placing, three 40-ton electrically driven revolving, self-propelling cranes were at work on the deck of the construction trestle, and they travelled on wide-gauge rails that permitted the cranes to span the other tracks on the deck. Each crane had a boom, 135ft. long, which could be moved vertically about 80 deg. Two of the cranes were used well-nigh exclusively for placing concrete, and the third crane was kept busy handling structural steel, erecting forms, and for other purposes.

(To be continued)

MR. G. O. WATSON, M.I.E.E., M.I. Mar. E. (Lloyd's Register of Shipping), has been re-elected President of the Institution of Engineering Inspection. The new Vice-Presidents elected at the same time are Group-Captain J. Sowrey, A.F.C., and Colonel A. W. Sproull, B.Sc., M.I. Mech. E., M.I.E.E.

The Measurement of Torsional Vibrations*

By R. STANSFIELD†

General Principles of Operation of Electro-magnetic Torsiographs

Introduction.—Recent developments in the use of high-speed multi-cylinder diesel engines for driving generators and for other applications in which the speed may vary over a wide range, have led to a need for more precise measurements of torsional oscillation amplitudes, particularly above 2000 or 3000 cycles per minute.

Calibrations of a belt-driven mechanical torsiograph made with various combinations of belt type and width, and alternative pen designs and lever ratios, show very clearly the difficulties met when the relatively high-frequency systems associated with multi-cylinder medium and high-speed engines have to be examined. Records up to 100 per cent. above, and down to only a small fraction of, the true amplitude may be obtained even when every practicable precaution is taken with the earlier designs of torsiograph used for unsuitable frequencies, and the need for expensive and special calibrating

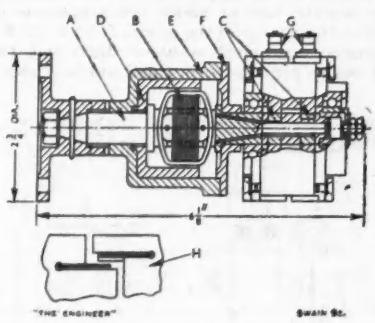


FIG. 1—*Torsional Vibration Pick-up Unit*

apparatus of precision manufacture precludes the general adoption of correcting factors.

It would be far from true to say that the majority of torsiograph records are useless for the purpose for which they are intended; but it would be equally untrue to assert that they approach the accuracy desirable for data which should constitute an ever-growing mass of freely exchanged information for both the expert on vibration problems and the engine designer.

The most important published development in electrical instruments for measuring vibrations is the M.I.T. (Massachusetts Institute of Technology) Sperry apparatus, described‡ at a meeting of the Institute of Aeronautical Sciences in New York. During that month the author was given details of an electro-magnetic pick-up unit built for the same purpose by the Chrysler Corporation, similar in principle to the type used in the Sperry system.

In both cases the primary unit consisted of a bipolar armature wound with a coil of wire and forced to oscillate with the engine shaft under examination; floating on the armature spindle was an "inertia" mass in which was mounted a permanent magnet, suitable stops maintaining the poles within small limits of the central position with respect to the armature core.

Above a certain low speed limit, depending upon the characteristics of the floating mass, the mass rotated at a substantially constant angular velocity, and thus oscillations of the armature shaft, reproducing those of the engine shaft, caused the turns of the armature coil to cut the magnetic field, giving a voltage output (at suitable slip rings) which varied directly as the angular velocity of the shaft.

In the Chrysler instrument the output from the unit was applied to a cathode ray tube after direct amplification, the angular deviations of the shaft being directly proportional to the amplitude of the trace on the tube at a given frequency, and directly proportional to the frequency for different frequencies.

The M.I.T. Sperry unit was coupled through an amplifier in such a manner that either an angular velocity or an angular deviation output could be obtained, the latter by means of a circuit attenuating the velocity amplitudes in proportion to their frequency. The output was observed by means of an electro-magnetic oscillograph.§

The apparatus to be described was developed from the Chrysler unit applied to the Standard-Sunbury engine indicator, which combines the use of either a direct or an integrated output with a cathode ray tube unit, the integrating circuit enabling the orthodox type of angular deviation record to be obtained. The pick-up unit in its final form is shown in section in Fig. 1.

Details of Construction.—The spindle A (Fig. 1) is slotted through the large-diameter central portion to take a tightly fitted armature B. This armature consists of a core of high-permeability laminations held in a brass casing made in halves and riveted together to form a rigid unit, the brass being formed with cheeks to take the winding. A coil of about 3000 turns is used and the ends are connected to short flexible multi-strand leads which are passed through the holes in the spindle during assembly and soldered to the insulated silver slip rings C. The armature is held in the slot in the spindle with two fitted bolts. The plane of the winding lies along the longitudinal axis of the spindle. The magnet, of cobalt steel, is shown at D, with poles which extend along the armature

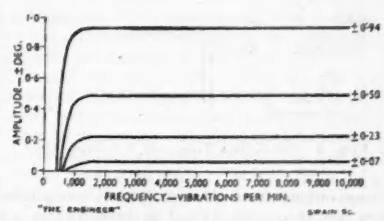


FIG. 2—*Calibration Curves for Pick-up Unit*

laminations. The pole shape is so selected that the integrated output per degree swing is constant for any position in the range of movement of the armature. The magnet is mounted in a bronze casing E, which is free to rotate on the spindle for 3–4 deg. to each side of the position at which the armature and magnet are centralised. The detail construction of the limit stops is important, and will be dealt with later. The bronze magnet casing is sealed at the outer end with a disc F, which also acts as an outer bearing, and a brush gear supported on ball bearings and carrying two sets of four "Silver-Morganite" brushes is carried on the free end of the spindle. The brushes in each set are connected to terminals G, from which the output from the unit is taken to the amplifier and the cathode ray tube unit.

Whenever possible, torsional vibration measurements should be measured with the unit directly coupled to the shaft under observation. Belt drive may have to be adopted in certain cases, but no effort should be spared to get a direct-coupled system if this can be arranged. The best belt drive is of uncertain accuracy at high speeds and frequencies. For this reason the unit described is designed primarily for direct coupling and the spindle terminates in a flange coupling recessed for location on a spigot on the engine shaft, and fitted on a cone on the spindle. A taper pin serves to locate the flange correctly in relation to the magnet poles.

The first units were made with a slot in the brass casing boss, and embodied a pin in the

* Institution of Mechanical Engineers, July 17th, 1942.—Abstract.

† Chief Research Engineer (Sunbury Laboratories), Anglo-Iranian Oil Company, Ltd.

‡ Taylor, E. S., and Morris, E. W., 1936, *Journal, Aeronautical Sciences*, Vol. III, page 129, "Harmonic Analysis of Engine Torque due to Gas Pressure."

§ A full description of the Sperry system is given in "Practical Solution of Torsional Vibration Problems," by W. Ker Wilson, 1941 (Chapman and Hall, London), second edition, Vol. II, pages 265–280.

spindle centralised in this slot, by which the swing of the casing was limited to a total of about 8 deg. The pin also acted as the driving member for accelerating the casing during general changes of speed.

Instead of the usual method of coupling the inertia mass to the drive with weak springs, the casing was almost filled with light ball bearing grease. This method proved completely successful, resulting in an aperiodic system with excellent damping, and without the need for frictional damping devices of uncertain action.

When the unit is rotated on a shaft, the driving pin of the spindle first advances towards the driven face of the slot in the casing, the damping effect of the grease packing preventing severe shock. When a steady running speed is reached the system is in equilibrium with the pin just touching one side of the slot. Should torsional vibrations occur at this speed the forward half of the first vibration drives the casing forward with the pin, but the inertia of the casing carries it along during the return swing so that the pin is then more than half a swing away from the slot face. On the second vibration a further relative movement between pin and slot takes place, and after very few complete vibrations the pin only just touches the slot at the extreme limit of swing, and the

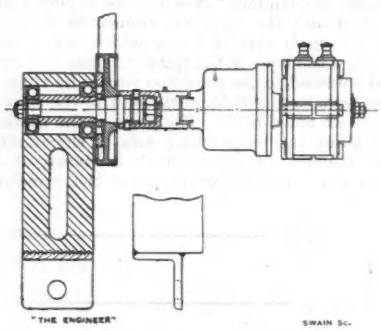


FIG. 3—*Belt-driven Torsional Vibration Unit*

voltage output from the coil after this negligibly short period is proportional to the instantaneous angular velocity of the vibrations. The integrated output measured on the cathode ray tube is proportional to the angular deviations. The armature tip has then made a track in the grease equal in length to the amplitude of the prevailing vibration of maximum amplitude. If the amplitude alters to a larger value, the same process of adjustment takes place, while if it decreases, centrifugal force acting on the grease fills up the track until it is again equal to the amplitude. When a general fall of speed occurs, the pin slowly takes up a position near to the opposite face of the slot without affecting the records. Successive revolutions give precisely the same trace on the cathode ray tube if the engine mean speed is constant from revolution to revolution, but the traces float up and down with changes of mean speed.

The construction described was satisfactory on engines with relatively heavy fly-wheels, and swings not exceeding half the total free travel between the limit stops, but when used on engines with light fly-wheels on the test bed coupled to water brakes which were almost without inertia, it was found that engine speed surges and very sudden changes in vibration amplitudes were sufficient to hammer the stops and ultimately to destroy them in two or three hours. There was also trouble due to shearing of the driving pin.

Even when the pin drive was altered to a drive effected by jaws on the driving coupling engaging with jaws in the casing, the hammering was sufficient to damage the unit in a very short time. Finally, the jaw type of drive was fitted with four tightly packed thin steel blades along each jaw face, electrically welded at the inner ends of the jaws to the main metal. This design is shown for one pair of faces at H, Fig. 1.

The brush gear is prevented from rotating by attaching two rubber bands led in opposite directions from one of the terminal posts to fixed points on the engine. These bands limit rotational freedom without overloading the ball bearings or the extension spindle. A rigid connection should not be used.

Accuracy of the records depends on the response of the amplifier unit and the pick-up and also on the limitations imposed by the need for damping and by the moment of inertia of the casing. Mounting the casing on ball bearings would reduce bearing friction, but only at the expense of necessary damping, and it has therefore no advantages.

The combined output of amplifier and pick-up on the integrating circuit is constant within ±1 per cent. between 60,000 and 1200 cycles per minute, and falls only 4 per cent. between 1200 and 120 cycles per minute.

It is obvious that if the spindle of the pick-up unit is moved very slowly the grease and bearing drag will carry the casing with the spindle, and no output will be obtained, and there will therefore be a range from the "unsticking point" over which the output will be attenuated. This range has been explored by using a Hooke's joint calibrating apparatus similar to that used for the Sperry system and to one described by Ker Wilson.

Response Curves.—Fig. 2 gives the response curves for the standard unit. The output reaches 90 per cent. of full response for small swings at a frequency of about 1200 vibrations per minute, and at about 800 vibrations per minute for swings of the order of ±1 deg. Full response is reached at about 1800 and 1400 vibrations per minute for small and large swings

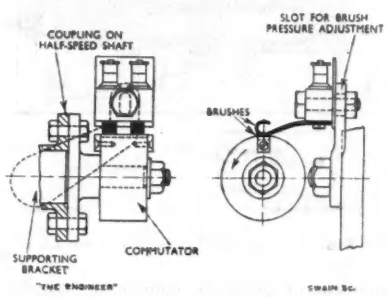


FIG. 4—*Arrangement of Sweep Commutator for Four stroke Engine*

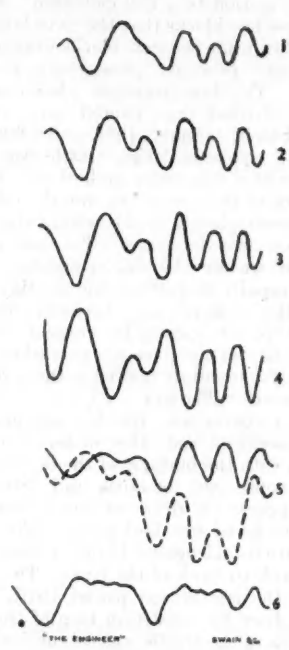
respectively. Thus the unit is adequate for most medium and high-speed engine problems, and operates without an objectionable resonance at low frequencies, and with inherent damping which eliminates the worst effects of large cyclic changes of speed. When it is necessary to indicate lower frequencies the inertia of the casing is increased by clamping an additional mass round it, and in this way vibrations down to 200 to 300 per minute can be observed with sufficient accuracy.

Calibration.—Although the preliminary complete calibrations required special apparatus, the routine checking of the instrument is extremely simple. For this purpose it is only necessary to apply a forced swing of known amplitude to the casing at any frequency above, say, 200 cycles per minute, and preferably between 1200 and 2000 vibrations per minute, and to measure the height of the resulting diagram on the cathode ray tube with the gain control at any suitable position.

The unit flange may be bolted to a table and a stout brass clamp with a laterally rigid extension rod about 1ft. long fastened round the casing. If the end of the extension rod is provided with a pin, say, ⅛in. diameter, it can be driven from a connecting-rod coupled to a small-throw crank on the shaft of a fractional horsepower motor, so that the swing is, for example, ½ deg. When the indicator sweep unit is driven from the same motor, a diagram is obtained showing the ½ deg. amplitude wave, giving the calibration required. The exact swing is best determined by fitting two insulated and adjustable stops, one on each side of the rocking lever, and adjusting these with the aid of a telephone earpiece and a small cell, so that the arm is just making contact with each stop at opposite ends of its travel. Feeler gauge measurement of the clearances between the adjusted stops and the lever and the distance from the stops to the centre line of the casing give the necessary constants for the swing to be calculated with precision. The average value for maximum sensitivity is about 45 cm. per degree total swing.

Once this calibration has been made, an approximate check can be obtained at any time by noting the amplitude of the diagram when the casing is swung by hand rapidly between its stops with the gain control set to one-tenth, and the speed switch in the "normal" position. Calibrations should be made with the amplifier low-tension battery voltage in the flat part of its discharge curve, and the high-tension battery correctly adjusted to about 240 volts.

Mention has already been made of the desirability of mounting the pick-up device directly on the shaft of the engine. This should either be turned with a suitable spigot during manufacture or fitted with a sleeve to take the



Scale, 3·6 cm. per deg. throughout.

Diagram 1, 1133 r.p.m.
" 2, 1040 r.p.m.
" 3, 1020 r.p.m.
" 4, 1000 r.p.m.
" 5, 910 r.p.m.
" 6, 835 r.p.m.

FIG. 5—*Unfiltered Torsional Oscillation Diagrams*

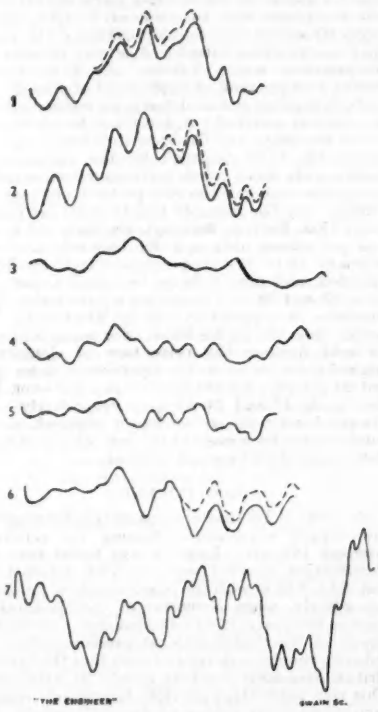
unit flange, and the face of the shaft should be quite true to avoid throw of the outer end of the unit spindle, as throw, if excessive, would overstress the metal, due to centrifugal forces exerted by the brush gear. A throw of 0·005in. at 5000 r.p.m. is the safe maximum tolerance for the standard pick-up, and the tolerance varies inversely as the square of the speed. Lack of truth in mounting does not appreciably affect accuracy, and, at the worst, only introduces a first-order wave of low amplitude; but every care should be taken to obtain true running.

Belt Drives.—An adaptor for belt drive is shown in Fig. 3. This consists of a light alloy pulley mounted on a ball-bearing spindle in a rectangular steel block which is bolted to the test bed or to an extension of the engine subframe, the pick-up unit being attached to the spindle with a muff coupling and Allen screws. The muff coupling is used in place of the usual flange to reduce as far as possible the moment of inertia of the vibrating system. The drive is arranged for a ⅛in. steel belt, 0·002in. thick, with a squarely made lap joint having about 1in. overlap, soldered with tinsmiths' solder. The driving pulley may be any convenient diameter from 3in. upwards—the smaller the better down to this limit—with the pulley centres at the minimum possible distance,

down to about 7in. Pulley ratio alters calibration in direct proportion to the ratio between the driving and driven pulley diameters, apart from a small correction for belt slip for which an exact allowance cannot be made.

The tension in the belt should be adjusted to a pull of about 30 lb. by means of a spring balance attached through the eye in the end of the steel block before the latter is finally tightened to the support, and the tension should be checked frequently. A correctly soldered joint does not break with a 200 lb. pull.

"Sweep" System.—In addition to mounting the pick-up unit, provision must be made for the "sweep" contacts to operate on the X-axis plates of the cathode ray tube. The standard sweep unit supplied with the engine-indicating equipment may be used, coupled directly to a shaft rotating at engine speed for two-stroke engines and at half engine speed for four-stroke designs. Alternatively, a small commutator of non-hygroscopic insulating material, such as "Carp" tufnol (red fibre is quite unsuitable), with a short metal segment across the rim, may be similarly driven. A pair of gauze brushes



Scale, 3·6 cm. per deg. throughout.

Diagram 1, 1500 r.p.m.; ¾ load.
" 2, 1450 r.p.m.; ¾ load.
" 3, 1240 r.p.m.; light load.
" 4, 1080 r.p.m.; light load.
" 5, 910 r.p.m.; light load.
" 6, 750 r.p.m.; light load.
" 7, 590 r.p.m.; light load.

FIG. 6—*Unfiltered Torsional Oscillation Diagrams*

loaded with leaf springs should bear on the rim to make the necessary contact for the sweep return once in each cycle of operations. A suitable device of this sort is shown in Fig. 4.

The system described—that is, the combination of torsional vibration pick-up unit, sweep contact, and Standard-Sunbury engine indicator—enables torsional vibration diagrams for one cycle of engine operation to be viewed or photographed on the screen of the cathode ray tube unit, these diagrams being equivalent to one complete cycle of a Geiger record. The addition of a variable-speed continuous camera and time marker to the outfit provides means for obtaining a continuous record over a wide speed range, which can be analysed as required.

Typical Unfiltered Diagrams.—Fig. 5 shows a series of diagrams from a six-cylinder two-stroke engine, each representing one revolution less about 7 deg. during which the sweep return is operating. Fig. 6 gives a similar series obtained from a six-cylinder four-stroke engine. The scales are the actual size on the cathode ray tube screen and do not refer to the reduced reproductions. In both cases the dotted lines are second traces displaced from the first by an amount equal to the angular deviation from one cycle to the next, thus the fifth diagram of Fig. 5 changes rather suddenly during half a revolution of the dotted trace by nearly 0·9 deg. The engine was running at a speed at which the friction damper was beginning to slip erratically, and the governor driving shaft was subject to violent forcing movements which led to this hunting. The approximate frequency of the displacement between the diagrams was about 1200 cycles per minute, that of the torsional critical vibrations being 5400 vibrations per minute.

Sudden changes of mean velocity between cycle and cycle, and during a given cycle when the engine is out of tune, with one or more fuel valves operating erratically, or when the governor shaft is being forced into sudden surges, give useful information regarding the general behaviour of the system, but often make it difficult to measure the heights of the waves at critical speeds with sufficient accuracy except by photographic methods. Such erratic conditions may also prevent accurate tracing of records. The surge can be very much reduced when desired by inserting a high-pass filter system between the pick-up unit and the amplifier. In the case examined it could be reduced to tolerable magnitude, without affecting the accuracy of important critical oscillations, by adding a 0·5 microfarad and a 0·1 microfarad condenser in series in the lead from the pick-up unit to the grid connection of the amplifier, with a 25,000 ohm resistance from the point between these two condensers to the opposite lead from the pick-up unit. This filter attenuates frequencies from 3000 cycles per minute downwards, and the 1200 cycle per minute surge is reduced to about one half. Better attenuation would be obtained with a similar system in which condensers of 0·25 microfarad and 0·05 microfarad are used, with the same value of shunt resistance, cut-off starting only a little above the natural frequency of the shaft. In both cases the scale of the diagrams is reduced 8 per cent. by the shunt resistance, and there is attenuation of all frequencies due to forced swings below the cut-off limit.

This direct type of diagram is sufficient for the determination of the most important critical speeds, and for measurements of amplitudes to within a small percentage; but harmonic analysis is necessary, as with other forms of torsiograms, for many of the critical vibrations of smaller amplitude, as well as for certain forced vibrations.

(To be continued)

Petrol Substitutes in South Africa

FOLLOWING the ban imposed recently by the Union Government on the sale and purchase of motor-cars, except under permit, a ban on sales of tyres and drastic rationing of the quantity of petrol to be sold to motorists, that section of the population has been seeking substitutes for one or the other. A great number decided to lay up their cars and return to the push bicycle, but the stocks of these were quite inadequate and were speedily exhausted, and there is little likelihood that more than a few will be imported as the demand has been the same in other countries. No substitutes worth mention have been found for rubber tyres, and, in short, the position is that motorists will have to use their present motor vehicles until they wear out, hoping meantime that "something will turn up." But to use their cars, fuel of some description has to be obtained to drive them, and so substitutes for petrol are being eagerly sought for.

To some extent this search had been going on in the Union for a considerable period before even the present war had become more than a small cloud on the horizon, and not without success. Torbanite deposits in the Union are rich in oil, and are being worked at a profit, but the output is but small compared with the needs of the country, and it is not considered likely that the deposits will be found capable of much extension or that further deposits of importance will be found. More promising is the production of power alcohol from molasses, which has been going on in Natal for a considerable time, and yields alcohol at a cost of 7d. a gallon.

It is now suggested that surplus sugar cane supplies might be used for the same purpose, either separately or with molasses. The prospects of success are considered good, but the output that could be expected, even with surplus areas and marginal lands utilised for production, would be small compared with the total petrol requirements of the Union. In fact, the production to be obtained from these sources would still be miserably inadequate. For this reason, and because increasing production would be a slow process while the need for supplies of fuel substitutes for petrol is urgent, experts strongly favour the use of gas, coal gas being preferred in the areas where coal is plentiful and cheap, and charcoal gas where wood is abundant and cheap. Coal gas was used in some parts of the Union during the last war the gas being contained in bags which were unwieldy and occupied much space when inflated.

To-day, however, gas from the municipal gasworks and compressed at 5000 lb. per square inch is led to the station storage bottles through a special separator, which completely removes any condensation and delivers the gas to the bottles in a dry state. The station storage bottles are of forged steel, having a volume, in the case in mind, of 5 cubic feet each, and tested to 7500 lb. per square inch. The vehicle storage bottles are made of nickel-chrome-molybdenum steel, 0·2in. in thickness. The weight of a bottle is approximately 100 lb. and the internal volume 1·76 cubic feet. Even if special measures are employed to burst them, the steel will not shatter into fragments, but will only rip and release the contents. The pressure in the vehicle bottles is 3000 lb. per square inch, and unsuitable for feeding direct to any form of gas mixer. A reducing valve is therefore used and the pressure is reduced in two stages, the second bringing it down to 2in. water gauge below the atmosphere. The vehicle used for the tests was of 2½ tons payload capacity, the six-cylinder engine having a bore of 3¾in. and stroke of 5in. The power developed on petrol is stated to be 75 H.P. at 2800 r.p.m. at sea level. At Johannesburg gas can be supplied at 2s. 6d. per 1000 cubic feet at works, while petrol cost about 1s. 8d. at the time the experiments were made, so that the fuel cost would be 1·154d. per mile on gas and 3·88d. on petrol. But the gas-driven vehicle has also to be debited with the cost of running the compression plant, and with interest and depreciation on the cost of the plant, &c., but it is known that these charges are carried profitably in England, and should be still more profitably carried in Johannesburg, and many other towns where coal is as cheap and there are municipal gasworks. Those authorities, such as steel works, collieries, operating coke ovens, &c., who have supplies of gaseous fuel available at low cost or as a by-product would appear to be in an enviable position for conducting their transport on very economical lines.

The substitute for petrol favoured by the Union Government, which it is adopting for use on Government-owned vehicles, and is recommending private owners to adopt, is charcoal gas. This, the Government states, will probably be the best alternative to petrol if the appre-

hensions with regard to its greatly reduced supplies in the Union or entire cessation of supplies are realised.

The Government is stated to be preparing measures for the production of charcoal producer gas as a source of motive power for vehicles. Should the petrol restrictions have to be made more severe in the future, the use of this gas is likely to become widespread in the Union, especially for commercial motor vehicles. In Sweden where wood is abundant over 60,000 motor vehicles are now operating on producer gas.

During the past year the Government has conducted many experiments with charcoal kilns with a view to designing an inexpensive and easily operated type suitable to local conditions. This work has been done jointly by the Fuel Research Institute and the Forest Products Institute in Pretoria, with the result that a charcoal kiln was recently exhibited in action in Pretoria, and gave very satisfactory results. According to the memorandum supplied by the Institutes, the weight of the generator devised by them varies from about 200 lb. to 400 lb. Its weight will, of course, reduce the payload of a lorry correspondingly. The cost of the fuel consumed can, it is stated, be reckoned roughly on the basis of 1½ lb. of charcoal per mile for a 3-ton lorry. With the commercial price of charcoal averaging 3s. for 60 lb., the cost per mile for charcoal for 3-ton lorries approximates to ¾d. A certain amount of petrol will be required for starting, and its cost should be added to the fuel cost per mile, to which must also be added labour costs incidental to running a lorry on charcoal, which are not incurred when using petrol. Disadvantages include loss of power and loading capacity, having to recharge the hopper with charcoal *en route*, carrying charcoal on the lorry and cleaning the apparatus. It is hoped that many private owners will adopt this system. Gas producers, it is pointed out, have been found specially suitable for stationary engines, of which so many are used by farmers, and farmers usually have enough wood to be able to make their own charcoal.

The Fuel Research Institute in its experiments to find a satisfactory type of kiln for the production of charcoal for gas producers, first investigated with a small brick kiln capable of producing about 500 lb. of graded charcoal per burn. The object was to provide a kiln suitable for farmers and others desirous of making charcoal for their own use. Owing to the success of this investigation, it was decided to experiment with larger kilns of the same type, for the commercial production of charcoal. A larger kiln was thus made which was capable of producing about 1750 lb. of graded charcoal per burn. This kiln gives excellent results, but it may possibly not be the best design as regards shape and size. In addition, the possibility of using a number of such kilns in a ring to obtain predrying of the wood by passing hot gases from a burning kiln into a cold kiln, will be investigated by the Institute. However, in view of the present demand for charcoal, it was thought desirable to give the existing information to the public as early as possible. Materials required for the large kiln are:—About 3000 medium quality bricks, about 2½ cubic yards crushed ouklip, seven pockets cement, 2½ cubic yards crushed stone, and 1½ cubic yards sand for making concrete foundations, nine 7ft. lengths of corrugated iron, five iron supports of 5ft. 7in. length. The whole burning operation takes 18–24 hours and the kiln is then allowed to cool for about 20 hours. During this period access of air must be prevented by sealing all places where smoke escapes, otherwise serious loss of charcoal may result, and the charge may ignite on opening the kiln. Black wattle wood was used in the experiment, but any reasonably hard wood can be employed.

Mr. J. Hamlin, City Engineer of Johannesburg, has informed the writer that he has had a producer plant fitted there, in which coke and charcoal are used. At that altitude (about 6000ft.) the fuel costs were about one-third of petrol, but, he says, "we found we had to reduce our load considerably." He also stated: "For loads over 5 tons there is nothing, in my opinion, to touch the steam wagon for our conditions. Up here coal is cheap, the gradients are heavy, and at 6000ft. you lose 18 per cent. of the efficiency of an internal combustion engine. It is the old story of picking the vehicle for the conditions."

Experiments, it may be mentioned, have been carried out to some extent at the city engineer's department at Johannesburg, using gas from the sludge at the sewage disposal works. The sludge gas as compressed consisted approximately of 72 per cent. methane and 28 per cent. carbon dioxide by volume, and the theoretical air-to-gas ratio for complete combustion was found to be 6·85 : 1. The vehicle used for testing was the one already mentioned. Running on the sludge gas the engine was more sluggish, especially on pick up, but still had ample power to do all that was necessary. At speeds over 35 m.p.h. the engine ran more smoothly than on petrol. The tests showed average gas consumption to be 19 cubic feet per mile. Average petrol consumption, 9 miles per gallon; 1 gallon petrol = 171 cubic feet sludge gas. Comparing the thermal efficiency obtained on sludge gas with that on petrol, it was found that for 1 mile on sludge gas 10,925 B.Th.U. are required, while with petrol 17,300 B.Th.U. are required. The results would be improved by using one of the simple methods for removing the two diluting gases, water vapour and CO_2. Free dry sludge gas consists of approximately 30 per cent. CO_2 and 70 per cent. methane, but as compressed it is saturated with water vapour. It is considered that much interesting research work could be undertaken on this. Although it would be unwise to come to any definite conclusions on the small amount of experience as yet obtained, it is considered that compressed sludge gas as a possible vehicle fuel is a subject that would be well worth investigating in detail.

During the writing of this article notice came to hand that the authorities have agreed to further increases in the wholesale prices of certain petroleum products, and these have been at once passed on to the consumers. The increases in wholesale prices are:—Petrol, 2d. a gallon, making the prices to motorists in the Cape Town area 2s. 4d. per gallon; power kerosene, 2d. a gallon; distillate diesel and furnace oil, 1d. a gallon; lubricating oil, 4d. a gallon; and grease, ½d. a gallon advance. The increases are effective throughout the Union.

In face of these increases it seems futile to deal with the position of crude oil traction *versus* compressed gas traction, and anyway little investigation has taken place with respect to the whole cost of running public vehicles on crude oil in South Africa. The general impression, however, seems to be that a crude oil driven vehicle goes about twice as far for the same price as a petrol-driven one. On the other hand, a crude oil engined vehicle appears to cost about 20 to 30 per cent. more than a petrol-engined vehicle. The extra cost of the crude oil engine is, in fact, more than that of the gas bottles and other fittings used on the gas-driven vehicle, and it is probable that with a fleet of vehicles the extra cost of the oil engines would go a long way towards paying for the gas-compressing plant, so that it seems that compressed town's gas might show up at least on an equal footing with crude oil in Johannesburg and on the Reef.

The possibilities of natural oil being discovered in the Union may become accomplished facts in time, if the Government carries out its intention of fostering prospecting for oilfields, but so far this and also the chances of natural gas being discovered in South Africa are too far beyond the sphere of practical politics to call for consideration.

LLOYD'S REGISTER SCHOLARSHIP.—The scholarship offered annually by Lloyd's Register of Shipping on the results of a competitive examination held by the Institute of Marine Engineers has been awarded to Harry Kay, a student at Sunderland Technical College, who is an apprentice of the North-Eastern Marine Engineering Company, Ltd., Sunderland. The scholarship provides for a three-year full-time course in marine engineering at a British university, leading to a B.Sc. degree.

British Standards Institution

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria Street, London, S.W.1. The price of each specification is 2s. 3d. post free, unless otherwise stated.

PAPER-INSULATED CABLES

No. 480. This revision of B.S. 480, metal-sheathed, paper-insulated cables for electricity supply, was started some years ago, but was temporarily suspended shortly after the outbreak of war. A comparison between the new specification and the 1933 edition shows that the number of sizes of conductors has been reduced; shaped conductors only are now standardised, whereas previously both shaped and circular conductors were provided for; and a single-voltage rating of 660 volts has now replaced the ratings of 460 and 1000 volts. Taken together, these three features of the new specification will effect a considerable simplification of the types and sizes of cables to be made and stocked. Price 3s. 10d. post free.

STRUCTURAL STEEL FOR SHIPBUILDING

No. 13. The revision of the series of specifications for steels for shipbuilding purposes has now been completed with the issue of B.S. 13, which covers structural steel for shipbuilding. The principal modifications introduced in the revision of this standard are as follows:—(*a*) A maximum limit of 0·06 per cent. of sulphur and of phosphorus has been imposed and a sulphur print test is required for rivet bar material. A dump test for rivet bars is also required. (*b*) The clause on freedom from defects has been amended by the inclusion of requirements which stipulate freedom from harmful segregation of impurities and prohibit patching or welding. (*c*) The ultimate tensile stress for plates (other than for cold flanging), originally 28 to 32 tons per square inch, and for bars and sections, originally 28 to 33 tons per square inch, has been amended, and now includes two ranges, namely, 28 to 33 and 26 to 32 tons per square inch. The purchaser is required to specify which range he desires when placing his order. For plates intended for cold flanging the percentage of elongation, originally 16 per cent. for thicknesses under ¾in. and 20 per cent. for thicknesses ¾in. and over, has been made 19 and 23 per cent. respectively. (*d*) Temper bend tests are no longer required, and a reduction has been made in the number of cold bend tests required for bars and sections.

RAW COPPER

No. 1035. In 1924 a series of specifications for raw copper were issued bearing the reference numbers 198–203. Later, it was found that the classification adopted was not very satisfactory, and did not fit in with the requirements of industry. Accordingly, when a reprint of the specification became necessary, it was decided that a new series based on the classification at present adopted in industry should be developed, and that the existing British Standards numbers should be withdrawn. This new publication provides for cathode copper, high-conductivity copper produced electrically and by a fire-refined process, and for three grades of tough-pitch copper in which conductivity is not specified. The specifications include requirements relating to surface defects, dimensions and tolerances on dimensions and marking. A note in the specifications states that a complementary document dealing with methods of sampling and of chemical analysis for the determination of impurities is also in preparation and should be available shortly.

SCREW THREADS OF SPECIAL DIAMETERS, PITCHES, AND LENGTHS OF ENGAGEMENT (AMENDMENT TO B.S. No. 84—C G 623)

In the 1940 edition of British Standard No. 84, "Screw Threads of Whitworth Form," tables were included which enabled the appropriate tolerances to be derived for threads of special diameters, pitches, and lengths of engagement. The tolerances were related to the length of engagement, and accordingly for threads of the same pitch and diameter the strict application of the tables provided various effective diameter tolerances as the length of engagement of the thread varied. These tables therefore required the use of different gauges for threads having the same pitch and diameter, but differing in length. With a view to reducing to a minimum the number of gauges required during the war, new tables of tolerances for special threads have been prepared. These simplified tables provide one effective diameter tolerance only for each combination of pitch and diameter. Copies of the amendment C G 623, giving these revised tables, may be obtained (gratis) from the Institution by sending a stamped addressed envelope.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quantities are f.o.b. steamer

Iron and Steel in the United States

In the United States the drive to produce iron and steel for the war industries is continuing at maximum pressure. Outputs have reached high levels, and the American War Production Board has announced that the pig iron situation has become easier, owing to the high production of existing furnaces and the appearance on the market of outputs of newly completed plant. It is not expected that further furnaces will be erected, but all the present production is immediately taken up and is under official allocation. Recently at Pittsburgh production was maintained at capacity at forty-three out of forty-five blast-furnaces, whilst the remaining two were under repair. At Youngstown the whole twenty-five in the district were in operation, and at Birmingham twenty out of twenty-one local furnaces were in blast, one being idle for relining. A new large-capacity furnace in Ohio, which was completed in five months, is scheduled to commence operations early in July. A similar furnace was put into blast in March, 1941, and achieved a record output last May of 43,866 tons. In the Ohio Valley district the Carnegie Illinois Steel Corporation have ten furnaces out of eleven in operation. Great efforts to maintain production are also being made in Canada, where eleven out of twelve furnaces are operating and production is at 94 per cent. of capacity. Two new furnaces are being constructed. There is a slight decline in the average production of steel, which is now at 98 per cent. of capacity, but is equivalent to an average output of 1,664,000 tons of steel ingots per week. The highest point reached in steel production was in May, when operations reached 99·6 per cent. of capacity. It is expected that the production of steel plates during July will reach 1,000,000 tons, most of which is required for the shipbuilding programme. Plate mill capacity, including universal and converted strip mills, increased to 1,012,000 tons in May, 1942, from 654,000 tons in December. This production was obtained by the conversion or alteration of continuous strip mills to roll heavier and wider material. The Carnegie Illinois Steel Corporation has changed the equipment of its 80in. hot strip mill to produce ship plates instead of tinplate, light strip, and special steels for automobile and household furniture. It has a capacity of 60,000 tons per month.

The Pig Iron Market

The demand for foundry iron is steady, and large quantities continue to pass into consumption. The light foundries which normally are the largest consumers of high-phosphoric foundry iron are not well employed, and their requirements are easily met. It is also reported that stocks of this class of pig iron are accumluating at the Midland furnaces which are supplying many districts in England which formerly obtained their supplies from nearer localities. For instance, the make of Cleveland foundry iron has been reduced to a point of insignificance as a result of the concentration of the industry in that district upon pig iron for the steel works, and local consumers now receive most of their supplies of foundry iron from Midland producers. Some stringency has developed in low-phosphoric pig iron as it is being used on a considerable scale as a substitute for hematite, and the Control is not disposed to grant licences freely for this class of iron if high-phosphoric descriptions can be used. A similar position rules in the case of refined pig iron. The use of this grade for many purposes for which hematite was formerly required has caused a certain amount of tightness, but where its use is essential consumers are able to secure supplies. Engineering foundries are taking considerable tonnages of refined and medium phosphorous irons, and using them for purposes for which in normal times hematite pig iron would be required. These foundries are kept fully employed on Government work in the form of castings for armaments and munitions, and their pig iron requirements are in the high-priority category. Attention in the foundry pig iron market is centred upon the concentration of the ironfoundries, and it is said that the uncertainty felt by many founders has resulted in a limitation of new business, since, until the position becomes clearer, many founders prefer to work upon their reserves. Once the scheme of concentration has been put through, however, it is probable that a movement will set in to re-establish the stocks that have been used. The basic pig iron position remains satisfactory, and although heavy tonnages are being steadily consumed by the steel makers, supplies are forthcoming in sufficient quantities to meet their demands.

The Midlands and South Wales

The steel works in the Midlands are maintaining a high rate of production, but outputs are quickly swallowed up by the insatiable demands of consumers employed upon war work. The demand covers practically all departments of the steel trade, but is perhaps less active in the heavy structural steel department than in others. Most of the works producing joists and sections would be glad to obtain more orders for the heavy sizes. Business in light joists and sections, however, is at a high level, and the re-rolling industry is experiencing an active request for small steel bars. The demand for strip is moderately good, but most of the re-rollers are kept well employed on bars and reinforced concrete rods. The most noticeable feature of the position, however, is the pressure to obtain plates. Whilst the demand covers light, medium, and heavy descriptions, it is chiefly for the latter two descriptions that the pressure from consumers is noticeable. Large tonnages are taken up by the shipyards, whilst tank makers also provide a considerable outlet. Lately the demands for collieries steel have been in evidence, which is partly because of the difficulties of obtaining the requisite quantities of timber. The demand for props is urgent, but although the steel works are experiencing a heavy pressure of demand from other consuming industries they are maintaining their supplies to the collieries. In some cases works which had accepted contracts late in Period II and did not complete them by the end of the quarter have had them carried over into Period III. There is a brisk demand for thick sheets, and most of the sheet mills are busy on special quality sheets for the Government. Supplies of raw materials to the Welsh steel works have been maintained at satisfactory levels, and production is kept at a high rate. The active demand for billets keeps the producing works fully employed, and a fair tonnage has been sent to consumers in the Midlands. More business is passing in sheet and tinplate bars, as lately the tinplate works have been covering their allocations. The tinplate industry, however, is quiet, owing to the Government regulations on the use and manufacture of tinplates, but a fair volume of business is passing on home account. The demand for heavy sections has not improved, but a good business is passing in lighter sizes.

North-East Coast and Yorkshire

The pressure upon the works in the North-East Coast district seems to have grown heavier during the past few weeks. Some indication of the urgency of the demand is shown by the fact that the iron and steel workers have agreed to forgo their annual summer holidays and receive extra pay instead. By this means the full productive capacity of the district will be maintained, and, even so, it is said, that it will no more than enable the works to maintain deliveries to schedule. The call for special alloy steels is particularly strong, and although production has been increased, it seems to make little difference to the pressure consumers are exerting to obtain supplies. There is little change also in the plate position. The demand appears to be principally for heavy and medium plates, which are required in large tonnages by the ship and tank makers. The production of semis also is on a heavy scale, but the whole production finds a ready outlet and the home production is supplemented by considerable imports from the United States. The re-rolling industry is well employed, and is taking up large quantities of semis, the official price for which remains at £12 5s. delivered in 100-ton lots and £12 2s. 6d. for sheet bars. The outputs of sheets have been growing of late, which is an indication that consumers are becoming more accustomed to the use of black sheets instead of galvanised, which are only made to special authorisation, which is rarely given. There has been no improvement in the demand for heavy joists and sections, and most of the works producing this description of steel are in a position to take on more orders. An active demand prevails for steel bars, and although the re-rollers have considerable orders in hand for the small sizes, the demand in this direction tends to diminish. Practically the whole of the Yorkshire steel industry is employed upon war work, and little steel is available for ordinary commercial purposes or for export. It is possible that the position in this respect may become even tighter as the year progresses. Owing to the difficulty the colliery managements are experiencing in obtaining their full requirements of wood, the demand for steel arches, roofing bars, &c., is growing, and seems likely further to increase in the future. All the basic steel plant is operating at capacity, and the raw materials position is satisfactory.

Scotland and the North

The urgent requirements of the armaments and munitions makers keep the Scottish iron and steel works operating at full pressure. Although the plate mills are working at capacity, and big tonnages are being produced, the demand from the shipyards, tank makers, and heavy engineering industries for medium and heavy plates is unabated, and it seems likely that these requirements will be maintained unchecked for an indefinite period. The call for ship plates is particularly heavy, and there is a tendency for delivery dates to be extended in spite of efforts which have been made to relieve the position. There is a big programme of work in hand at the shipyards and the demand from this industry and from the other big consuming industries taxes the resources of the steel works. Next to the demand for plates, probably, comes the call for special and alloy steels, and the producers of this material are experiencing an insistent demand. Consumers' requirements are being met, but the producers are being severely pressed to maintain deliveries. Large tonnages of shell steel are being taken up by the munitions makers, and heavy as the demand is it appears to be gradually increasing. Business in billets is maintained at a high rate, and although the production by the British works is pressed to the utmost, the consuming industries are able to take the whole output without difficulty, and are receiving considerable supplies of imported billets. The sheet industry is well employed; on the other hand, the re-rolling industry is experiencing rather a quiet period, which is the more disappointing as raw materials are in satisfactory supply. The conditions in the Lancashire market are similar to those ruling in other steel-producing districts. Plates of all thicknesses are required in large quantities, but there are indications that the demand from the boilermaking industry will decline in the not distant future, as new orders for boilers show a tendency to taper off. The demand for bars is on a considerable scale and the engineering industry continues to take good supplies of the larger sizes. Business in small steel bars is less active. The steel works on the North-West Coast are fully employed on Government work.

Copper, Tin, Lead, and Spelter

The feature of the non-ferrous metal position is the steady expansion in the demand. This applies to practically all the four principal non-ferrous metals. The Control is carefully watching over their distribution, and the metals are only released for use in the national effort. Supplies of copper continue to reach this country in sufficient quantities to maintain full supplies for the war industries, and even should the expected increase in the demand for copper for the production of brass take place, there is little doubt that the Control will have the situation well in hand. The National Association of Copper Cylinder and Boiler Makers has circularised its members, pointing out that owing to further restrictions in the allocation of copper, it will be necessary, before further orders can be executed, for their suppliers to receive from them an undertaking that the copper delivered will be used only for replacement purposes, and that a similer undertaking must be received from their customers. American statistics give the April production of copper in Chile, Peru, and Mexico as 51,342 tons, compared with 49,212 tons in the previous month. . . . The campaign to restrict the use of tin for essential purposes only has effected a big saving in consumption, both in Great Britain and the United States. Further restrictions are being imposed in the latter country, whilst in Great Britain the use of tin for tinplates and in the manufacture of solder and alloys has been greatly reduced. . . . The use of lead in Great Britain is now practically confined to products required for war purposes. The restrictions upon supplies imposed by the Control extend to lead products, and it is not easy to obtain pipes or sheets. The price of ground white lead has been advanced £1 per ton, and of litharge, red lead, and orange lead by 10s. The position is also somewhat stringent in the United States, and there also a drastic curtailment of consumption has been effected. In June it is estimated that the consumption of lead in the U.S. was 57,000 tons, compared with 75,000 tons in May and 85,000 tons in April. . . . Whilst regular supplies of spelter continue to reach this country, the position in Great Britain has been stringent almost from the outbreak of hostilities. The Non-ferrous Metal Control, however, is careful to see that firms employed upon war work obtain their supplies, but there is no margin available for ordinary civilian purposes.

Notes and Memoranda

Rail and Road

JAPAN REOPENS THE RAILWAYS.—The wrecked railway from Manila to Batangas, which is approximately 70 miles long, was reopened on July 1st, and that from Manila to Kalumpit, 35 miles long, on the following day. About the same date a regular public passenger train service was inaugurated between Bangkok, the capital of Siam, and Singapore.

NO WOOD FOR PRODUCER GAS.—It is thought that Germany has on the roads about 150,000 mechanically propelled vehicles driven by producer gas, but so short has the supply of wood become, and so great the need for more timber for the pulp industry, that the German Government has now prohibited the manufacture and installation of gas generators fuelled with wood.

ELECTRIFICATION IN HOLLAND.—Two short lines have been electrified by the Netherland Railways operating from Utrecht. They are the sections from Utrecht to Amersfoort and from Utrecht to Hilversum. Both are of standard gauge and double track. Stopping trains now cover the Amersfoort line in 24 min., against 38 min. by the steam-worked trains. On the Hilversum line the journey now takes 18 min. compared with 25 min. previously.

THE "ALLEGHENY" TYPE OF LOCOMOTIVE.—This is the name adopted by the Chesapeake and Ohio Railway Company for ten freight locomotives of large size and distinctive design, with a wheel arrangement 2–6–6–6, not previously used in locomotive construction. The new engines are already in service in the heavy coal freight traffic moving over the route traversing the Allegheny Mountains, between Clifton Forge, Va., and Hinton, W. Va.

WOOD-BURNING PRODUCERS.—Swedish transport authorities have been investigating the rival claims of wood and wood charcoal for vehicles using producer gas. Over 120 vehicles were tried out with power derived from 22 types using wood and 16 wood charcoal. The down-draught class of producer was found to give the best results with wood fuels, but the cross-draught type was best with charcoal. On the road tests the wood-burning producers showed generally better starting characteristics after stops than did the charcoal burners.

Air and Water

A DUTCH WARSHIP.—The Netherlands Navy's newest destroyer, the "Jerk Hiddes," built on the Clyde, was named after a Dutchman killed in a battle with the British Fleet nearly 300 years ago.

SWEDISH AIR TRANSPORT.—Statistics published recently show that the national air traffic undertaking of Sweden returned for 1941 a profit of Kr. 1,048,964, a reduction of more than 50 per cent. compared with 1940; 652,514 miles were flown during the year, as against 1,014,825 in 1940.

NAVAL CONSTRUCTION AT PITTSBURGH.—A new war plant, which, it is estimated, will cost 8,500,000 dollars, is nearing completion at Pittsburgh. It will be utilised for the construction of a number of special-purpose craft for the Navy, and will be wholly owned by the Navy and operated by the American Bridge Company under lease.

THE DAVIS DAM.—A contract has been placed for the construction of the Davis dam, situated about half-way between the Boulder and Parker dams on the Colorado River. This dam is to be an earth and rock-fill structure, 138ft. high above stream bed, and 1600ft. long at the crest, and is being built solely for power generation purposes.

GOLDEN GATE BRIDGE.—Instruments installed recently on the Golden Gate Bridge at San Francisco for accurate recording of movements that occur under wind loads include a wind velocity recorder, a wind directional recorder, and a non-sensitive recording seismograph. Vertical and horizontal graduated boards at midspan will facilitate observations to measure movement in these two planes.

STRETCHERS IN SHIPS.—The Ministry of War Transport has issued a notice to shipowners and shipmasters, which describes and gives instructions for the use of Neil Robertson stretchers, two of which are to be carried on board every foreign-going merchant ship. The patient is wrapped up like a mummy so that he can be hoisted vertically or carried horizontally, and the stretcher has proved of great value not only on board ship but also in all places where an injured person has to be extricated from an awkward position. It is made of stout canvas, 65in. long, cut in such a shape that there is a portion for the head and neck, 17in. long and 12in. broad; a portion for the chest 14in. long and 42in. broad; a portion for the small of the back, 6½in. long and 14in. broad; and a portion for the hips and lower limbs, 27½in. long. At the upper end it is 38in. broad and at the lower end 25in. broad. The whole stretcher is stiffened by bamboo slats which are sewn to the canvas.

C.P.R. AIR LINES.—As a result of air line purchases made during the past year, the Canadian Pacific Railway Company now ranks as one of the world's largest commercial air line operators. An article in the *Railway Gazette* shows that the air services now associated with the C.P.R. include practically all the air transport companies west of the Maritimes to the Pacific Coast and north of the trunk route of Trans-Canada Air Lines (the Canadian National Railways associate) to the Arctic. This vast aerial network has more than 100 aircraft, more than 1000 flying and ground personnel, and an annual flying mileage of 5,000,000 miles.

Miscellanea

ALUMINIUM TO BE MADE NEAR NEW YORK.—The U.S.A. War Production Board has authorised the construction of a bauxite plant by the Aluminum Company of America in the New York area. Approximately 30,000,000 lb. annual production is expected.

NEW ZEALAND HUNTS FOR MERCURY.—Cinnabar is known to be widely distributed in New Zealand, but the important deposits are those in the Puhipuhi district, where the mine near Whangarei, 95 miles north of Auckland, has been reopened by Mercury Explorations, Ltd. The prospect of recovery of mercury from low-grade deposits in other districts is also being investigated.

BERYLLIUM AS A HARDENER.—The addition of the metal beryllium to copper and nickel is a metallurgical process that is finding increasing favour here and in America. Economical methods of reducing the metal from its ore have been worked out, and beryllium is now used to convert copper or nickel into alloys with hardnesses comparable with that of steel. The desired result follows the addition of only 2 per cent. of beryllium. Not only does beryllium confer hardness on copper and nickel, but it is stated to increase their resistance to fatigue.

SAND-LIME BRICKS.—The Building Research Station of the Department of Scientific and Industrial Research has issued Wartime Building Bulletin No. 20 on "Sand-Lime Bricks" (H.M. Stationery Office, price 3d.), which provides in a concise form up-to-date information on the properties and uses of sand-lime bricks, including points of direct wartime interest, such as fire resistance and resistance to blast and earth shock effects and splinter penetration. It is noted that the quality of sand-lime bricks is defined by the newly revised British Standard Specification for Sand-Lime Bricks (No. 187—1942).

PRESTRESSING.—A company has been formed in Canada to extend what is known as the preload system for tanks, silos, domes, pressure vessels, and all containers and carriers of liquids and dry materials. The preload system is a patented method of prestressing reinforced concrete structures so as to place the concrete under initial compression, both vertical and horizontal, in excess of all tensile stresses arising from shrinkage, temperature contraction, hydraulic loading, plastic flow, &c. Thus it is claimed that the concrete is maintained in a state of compression under optimum loading conditions, and is relieved of any tendency to crack. A notable example is a new 200,000-gallon preload elevated water tank erected at Ste. Anne de Bellevue, Que. This tank has an internal diameter of 35ft. 6in. and is 120ft. high.

MERCURY IN THE UNITED STATES.—A new, high-grade deposit of mercury-bearing ore, which may prove of great importance to the nation's war production schedule, has been discovered by the U.S. Bureau of Mines in the Yellow Pine area of Valley County, Idaho. The discovery was made during explorations undertaken as a part of the Department of the Interior's war programme for mineral development. Tests of the latest drill samples taken in the Yellow Pine region show the existence of ore averaging 11 lb. of mercury per ton, with one 5ft. section averaging 22 lb. per ton. The ore lies in a body, 24ft. thick, but the other dimensions have not been determined. Exploration of these deposits began in August, 1941, four months before the United States entered the war. Before the discovery of the richer ore, engineers of the Bureau's Mining Division estimated that the deposits contained more than 400,000 tons of low-grade ore rated at 3 lb. of mercury per ton. In addition to the work in the Yellow Pine region, engineers are conducting explorations for mercury-bearing ores in Nevada, California, and Oregon.

A BIG HAUL OF SCRAP.—The U.S.A. Salvage Officer has ordered the sale of 7660 tons of steel derived from the Tacoma Narrows bridge towers and cables. This was the suspension bridge which collapsed a year and a half ago in a high wind.

A CHANGE OF NAME.—The Council of the Institute of Estimators—Planning and Time Study Engineers has acceded to the request of a large body of the members and revised its name, which in future will be the Institute of Economic Engineering. The change of title will not affect policy. Mr. E. W. Barrell, 78, Abbotsbury Gardens, Eastcote, Middlesex, is secretary.

EXPORTS TO SOUTH AFRICA AND SOUTHERN RHODESIA.—The Board of Trade has made an Order which will come into force on August 3rd, and will have the effect of making exports of all goods to South Africa and Southern Rhodesia subject to export licence. Under another Order made by the Board of Trade which will also come into effect on August 3rd, all export licences for these destinations (other than licences issued to the respective High Commissioners, and to certain semi-official bodies) issued before July 3rd will be revoked. The object of these Orders, which have been made after consultation with the Union and South Rhodesian authorities, is to restrict the export trade with these countries in order to bring it more closely into line with the limited shipping space available for commercial cargoes under present conditions.

MINERALS IN THE PHILIPPINES.—The U.S.A. has been taking stock of its losses owing to the invasion of the Philippines. Iron ore production was near the level of 1,000,000 metric tons annually, but as there is no domestic iron and steel industry in the islands, Japan took practically all of it, and also most of the copper, although a smelter at Lepanto had been constructed to provide blister copper or high-grade copper matte for the United States. Although some of the chromite deposits of the Philippines were comparatively low grade, they were important in view of the large reserves available. These deposits, together with others of higher-grade ore, are also significant because they are the principal source of supply of this mineral under American control. Deposits of manganese are fairly widespread throughout the Philippines, but with few exceptions they are individually small.

Personal and Business

MR. G. W. BYNG has been appointed an executive director of Dorman, Long and Co., Ltd.

COWANS, SHELDON AND CO., Ltd., has transferred its London address to 16, Gwendolen Avenue, Putney, S.W.15.

MR. L. B. UNWIN has been appointed president and Mr. W. M. Neal vice-president of Canadian Pacific Air Lines, Ltd.

DR. H. B. NISBET has been appointed to the new post of Lecturer in Fuel Technology at the Heriot-Watt College, Edinburgh.

PROFESSOR C. L. FORTESCUE has been elected President of the Institution of Electrical Engineers for the year beginning September 30th.

MR. M. G. TWEEDIE has resigned, on account of ill-health, the honorary secretaryship of the Institution of Railway Signal Engineers. Mr. L. F. Baker has consented to serve in his place.

LIEUT.-COMMANDER E. Basil Green, R.N., assistant managing director of the Royal Doulton Potteries, has been appointed Deputy Regional Commissioner for Civil Defence in the S.E. Region. Lieut.-Commander Green served as Staff Officer to Captain Lord Monsell, R.N., in 1939–40. He was released from active service at the request of the Ministry of Supply, to return to his company to deal with production.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Institution of Automobile Engineers

Wednesday, Aug. 19th.—LUTON CENTRE: George Hotel, Luton. General meeting. 6.30 p.m.